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# THE PRACTICAL ENGINEER

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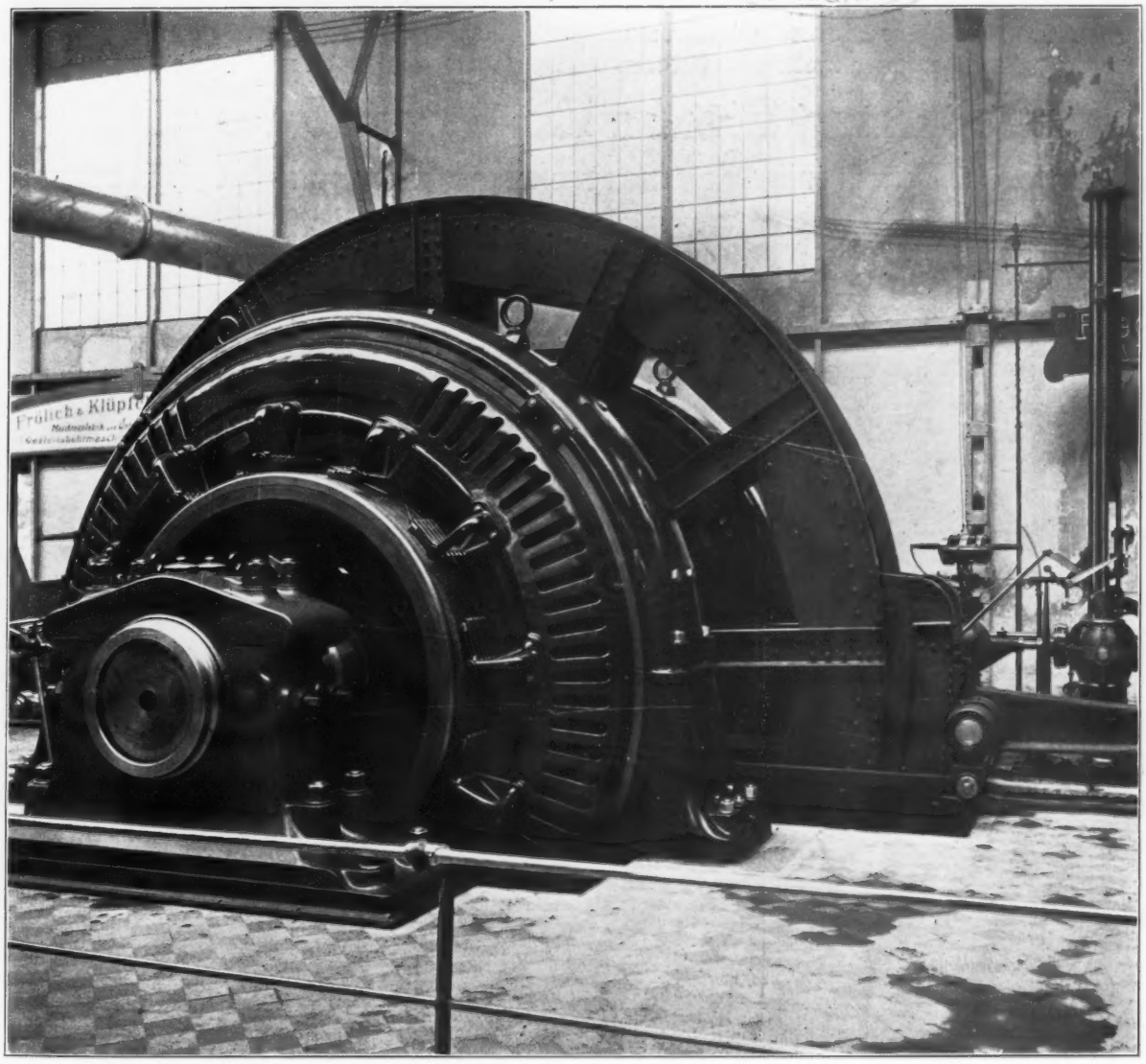


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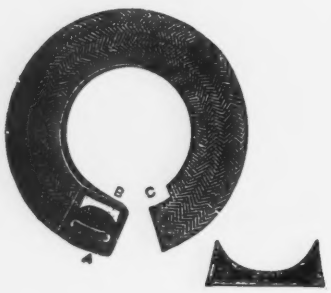


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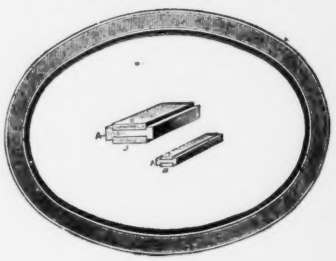

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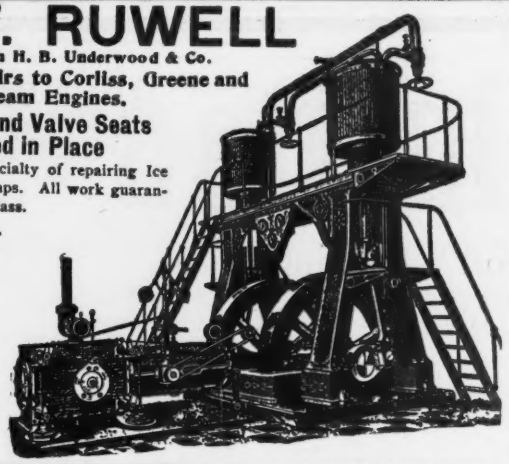

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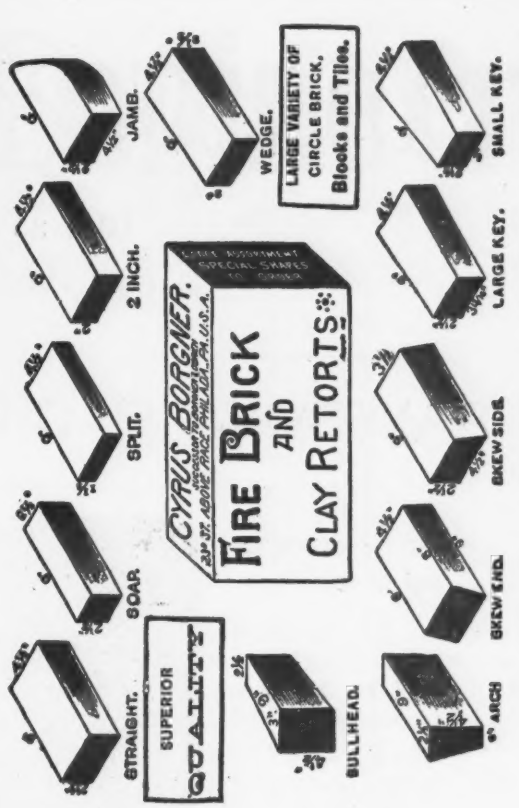


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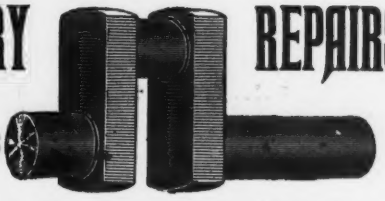

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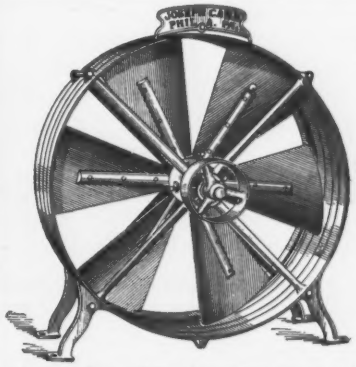

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The
# Practical Engineer

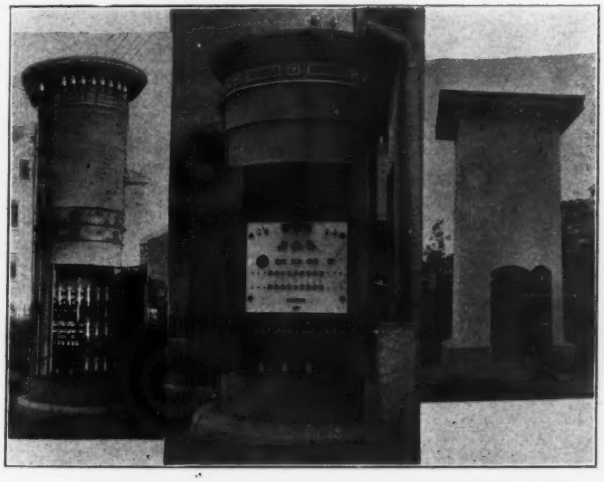
A monthly journal, devoted to the economical generation and utilization of power and to the interests of stationary engineers

VOL. VIII PHILADELPHIA, JULY, 1904. No. 6.

## An Austria-Hungary Power Transmission Development.

BY FRANK C. PERKINS.

The hydro-electric plant in Tirol, Austria, has a total capacity of 2000 horse power. It is a three-phase power and lighting installation and was constructed near Zurich, Switzerland, the turbines being of the Leffel wheel type of Roesch



Low Pressure Side of Low Pressure Transformer House. High Pressure Side of High Pressure Transformer House. Terminal Tower. Junction of Overhead and Underground Conductors.

design. The hydraulic work and cranes were installed by the machine works of J. I. Roesch.

The current is transmitted by overhead and underground transmission lines, for both light and power from this station to Bozen and Gries, at a pressure of 3600 volts. The two overhead transmission lines each consists of three bare copper conductors 7 mm. in diameter, one group being utilized for the lighting current and the other for the power current. The overhead lines are carried on wooden poles 45 feet in length, and 7 to 12 inches in diameter at the top, the poles being placed 4 to 6 feet in the ground. The transmission line is installed along the left bank of the Eggenthalerbach as far as Gansnerhof, where a high tension transformer tower is located; the line then crosses the stream, passing along the right bank to Eisack, where a terminal tower is located. This tower contains the necessary connections and lightning arresters for the junction of the overhead lines with the underground cables. The total length of the overhead lines is 2500 feet, the weight of copper used being 3700 pounds, while the total length of underground cable employed is 32,000 feet, of which 16,400 feet is a three-conductor cable of 50 square millimeters cross-section; 9800 feet is a three conductor cable of 25 square millimeters section, and the remainder, which has a section of 15 square millimeters of copper for each of the three conductors, is 5800 feet in length. These cables are insulated with paper, lead covered and iron armoured and are laid 30 inches below the surface. The terminal tower is 22 feet high, of rectangular

Rear of Switchboard in Power House.

section 6 feet by 6 feet, the cement walls being 15 inches in thickness. The underground cables conduct the current for light and power to various transformer houses in Bozen and Gries, where the current is transformed to lower voltages for the overhead distribution circuits.

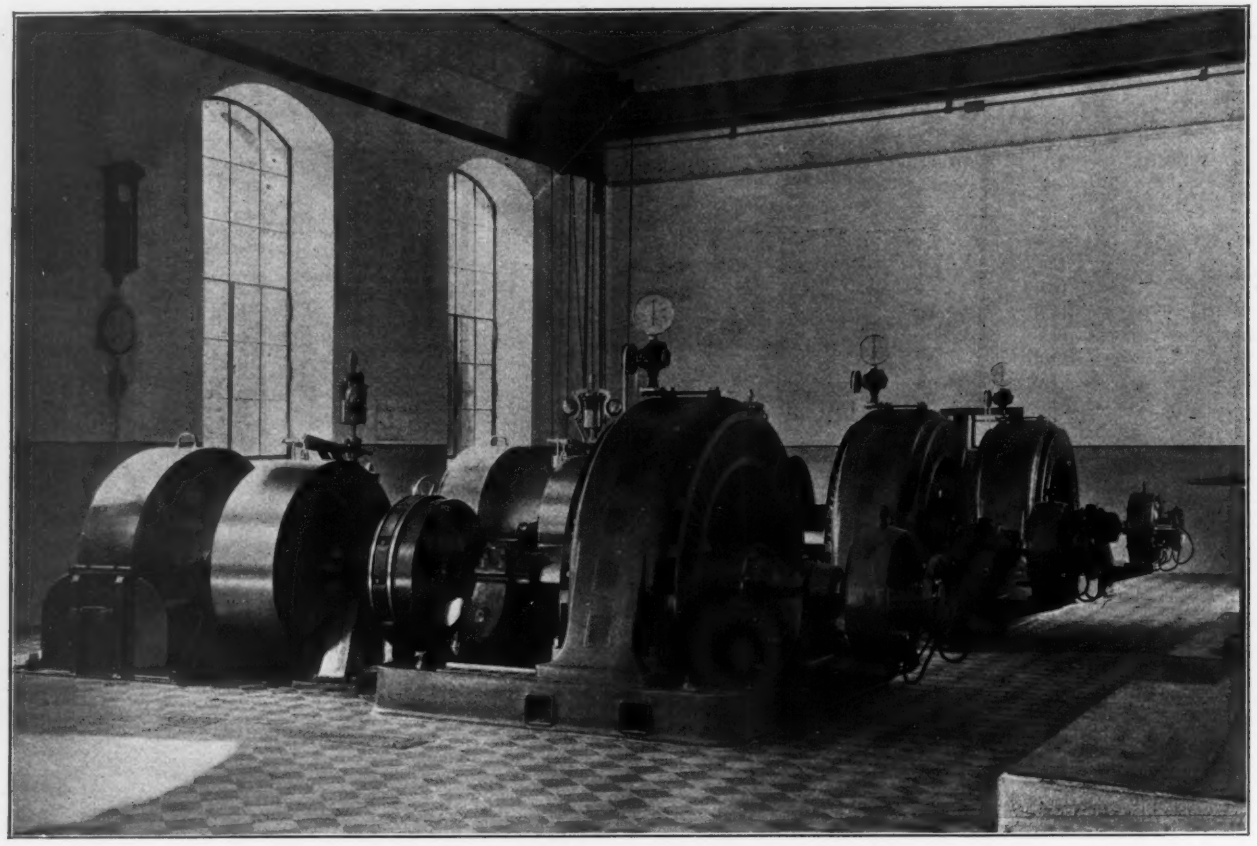
On account of the necessity of providing drinking water for these towns, it was thought best to combine the water system with the power transmission plant, water for both being obtained from the same source.

The necessary water for this hydro-electric station is obtained from the Eggenthalerbach, which is reinforced by the waters of the Zangenbach and Welschnofenbach and empties into the Eisack at Kardaun. The water supply for the electric station consists of 1000 liters per second, the dam being located a distance of 2.1 miles from the power house. The dam is 195 feet in length and 14 feet thick and lies 1750 feet above the sea level. The water is carried by means of a canal, 39 inches wide and 8 feet high, a distance of 2.2 miles to the Wasserschloss which is located on the side of a mountain above the power house, 1734 feet above sea level. At this point a steel pipe 1352 feet in length conveys the water down to the power house, the net fall being 676 feet. This pipe is ¼ inch thick near the upper part and ⅝ inch thick near the power station, the diameter of the pipe being 36 inches, and it is constructed of 20 foot lengths, wrought iron being employed at the joints near the top and cast steel near the power house. The maximum discharge is 4.6 feet per second or the equivalent of 2000 horse power.

The power station is located near Kardaun on the left bank of the Eggenthalerbach about 2280 feet from where the latter empties into the Eisack. The station has a floor area of 4114 square feet, of which the turbine and generator room occupies 3025 square feet, the switchboard room 280 square feet and the workshop 325 square feet.

In the turbine and generator room are installed five units, having a total output of 2000 horse power, an overhead traveling crane of 7.5 tons capacity being provided for handling the heavy parts in mounting and repairs. Four of the turbine sets are in use, the fifth being held in reserve in case of emergency. The station is lighted by a number of incandescent lamps and three arc lamps in series, using a current of 15 amperes.

The turbines each develop 500 horse power under a head of 676 feet and use 56 gallons of water per second. They operate at a speed of 500 revolutions per minute and are direct connected to Oerlikon three-phase alternators supplying currents of a frequency of 50 periods per second at 3600 volts. The turbines have an efficiency of 80 per cent. and the governors control the speed within 3 per cent. at 50 per cent. change of load and within 6 per cent. at 100 per cent. change of load. Each set is provided with a fly wheel weighing 7150 pounds, measuring 4.8 feet in diameter, and the turbines and generators are connected by means of flexible insulating couplings, as shown on cover.



Interior of Power House at Zwolfmalgreien, Tirol, Austria.

The bore of the armature of the three-phase generators is 4.66 feet and the armature has 72 slots with 2 slots per pole per phase and two sets of 18 coils. Each coil has 17 turns of two copper conductors having a section 4 mm. x 4.6 mm. The diameter of the field magnet is 4.63 feet giving an air gap of 1-5 inch on each side. The twelve field exciting coils have each 40 turns of copper stip 3 mm. by 33 mm., the insulation being .5 mm. in thickness between the strips. The exciters supply a current of 200 amperes each and are supplied with 12 carbon brushes measuring 24 mm. by 16 mm. The exciter

for each alternator is mounted on the same shaft with the revolving field outside of the main bearing, upon a small shelf extending from the alternator frame provided for the purpose.

High Pressure Pipe Line to Power House.

The switchboard room is located at the right of the generators and is provided with the usual measuring instruments and switches for controlling the exciters and three-phase machines. A 7 kilowatt transformer is provided for operating the arc and incandescent lamps for the station. The two transmission lines leave the power house through two windows after passing the usual cutouts, lightning arresters and kicking coils.

The transformer houses are of the cylindrical tower type with three doors, one of which allows the examination of the high tension connections, another the low tension connections and the third the step down transformers. These transformer stations are 20 feet high and 5.25 feet in diameter. They receive the current from the underground cables at high tension and after transforming to a lower pressure it is carried out of the tower to the overhead lines.

The lighting circuits at Bozen and Gries are supplied by twelve transformers of 137.5 kilowatts capacity, the current for lighting having a pressure of 150 volts. There are in operation for streets and residence lighting about 2000 lamps of 5 to 25 candle power. On the power circuits, all motors having a capacity of over 5 horse power are provided with separate transformers. The current is measured by meter and contracts are also made at standard rates per lamp per year and per horse power per year, the service being provided day and night.

———o———

### Heat Lost by Radiation.

The amount of heat lost by radiation from bare pipes containing steam at 100 pounds pressure has been estimated to be about equal to two tons of coal a year for each 10 square feet of pipe surface. It has also been found that 88 per cent. of this loss can be saved by the best pipe covering.

## THE STEAM TURBINE.

### The Fundamental Principles upon which this Important Type of Steam Motor Works.

By C. M. Jones.

In a steam turbine, the energy of the steam is absorbed by impact or by reaction, or by both, in the same general manner as the energy of a stream of water is absorbed by an ordinary mill turbine.

In a mill or water turbine, the water usually acts but once on the blades, but in steam turbines intended for moderate velocities of rotation, the steam acts on blade after blade in succession, for the reason that the efficiency of a single impact is very small unless the blade moves at a very high rate of speed.

In Fig. 1, let T be a nozzle from which issues a stream of fluid, and suppose that at L the fluid moves at a speed of, say, 10 feet per second. Let OPR be a cupped vane on which the fluid glides as shown and suppose that the vane's speed in the direction of the arrow V is 5 feet per second.

The fluid will glide upon the vane at O with a velocity of 5 feet per second; that is, it will move over the surface at O at a speed equal to the difference of the speeds of fluid and vane. At P, the stream will move at right angles to the motion of the vane and if its cross section be the same as at O, which is usually assumed even where there is nothing to restrict its change, its speed of gliding over the vane surface will be unchanged, or 5 feet per second. At R, its relative velocity will also be 5 feet per second and as the vane surface is moving in the direction of the arrow V at 5 feet velocity, the stream at N stands still, relatively to the earth, or drops inert, and as its motion has been taken out by the action of the vane alone, its entire energy has been absorbed by the vane.

If the vane moved slower than one-half the velocity of the jet at L, the stream at N would move backward with some velocity and would therefore not have given out all its energy of motion to the vane. Also, if the vane moved faster than

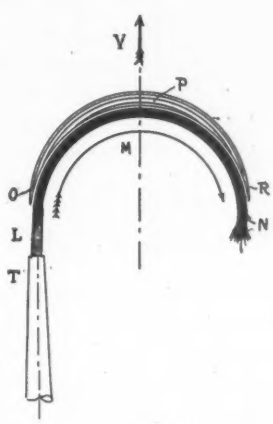



Fig. 1.

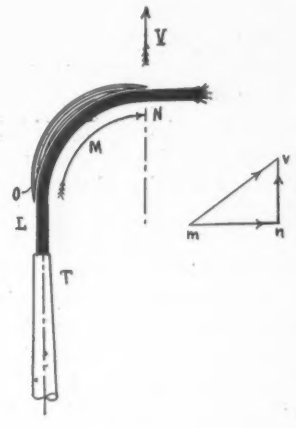



Fig. 2.

half the stream velocity at L, the fluid will glide around the curve at less relative velocity, and at N will move in the same direction as the vane relatively to the earth although gliding over the vane surface itself with some velocity in the backward direction. This causes the stream to exert less pressure on the vane and to give out less energy than in the first in-

stance, the motion of the stream at N relatively to the earth being the measure of the energy lost. To secure full efficiency, therefore, a single cupped vane must move at half the speed of the jet. Friction and eddying of the stream itself modifies this speed of greatest efficiency to some extent, the exact speed of vane being readily found by experiment, as is the practice of builders of such machinery.

In Fig. 2 the vane is but partly "cupped," allowing the escape of the fluid at right angles to the vane motion also shown by the arrow V. The same method of analysis may be used as for Fig. 1, for the speed at which the stream of fluid flows over the surface of the vane at O is equal to the difference between the velocity of the vane and the fluid at L; and this speed of gliding over the surface is practically constant for all parts of the vane, unless there is a second guiding surface to force a change of stream section.

At R the fluid leaves the vane at right angles to the vane's direction of motion, and also since it remains in close contact with the surface at that point, as elsewhere, it has in addition the same motion as the vane in the direction of the arrow V.

If *mn* be set off by scale equal to, and in the direction of, the gliding velocity of the stream; that is, the velocity of its

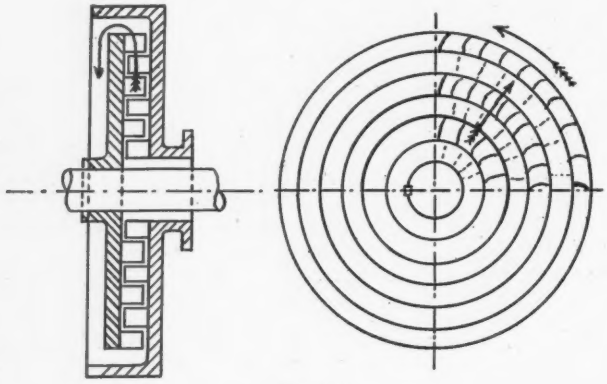


Fig. 3.

"rubbing" over the vane surface, which is its relative motion as it leaves the vane and if also *nv* be set off equal to and in the direction of the vane's motion or velocity, the vane's mean circumferential velocity, if it be carried in a circular path, as a bucket revolving around an axis, a line *mv* will give the direction and velocity of the escaping fluid relatively to the earth, that is, its final actual motion and the difference between its energy of motion at L and that of escape at R will be the energy absorbed by the vane.

The efficiency of the vane is the fraction of the energy which is absorbs, and is found by dividing the latter by the total energy, or energy of the issuing stream at L, and since the energy is proportional to the square of the velocity, the efficiency may be found by subtracting the square of the actual stream velocity at R, equal to the square of *mv* in Fig. 2, from the square of the velocity of the issuing stream at L and dividing the difference by the latter quantity; or, let S be the velocity in feet per second of the stream at L and *s* the actual velocity (as at N) at the "trailing edge" of the vane (or *mv* in Fig. 2) then the efficiency, $E = \frac{S^2 - s^2}{S^2}$

It was shown for Fig. 1 that the actual velocity, that relative to the earth, at N was zero for the vane moving it half the stream velocity, in which case *s* is zero and $E = \frac{S^2 - 0}{S^2} = 1$, or full efficiency, as was stated. In actual practice, water turbines using the cupped vanes or buckets, such as shown in Fig. 1, have given out as high as 88 per cent. efficiency, 12 per cent. being consumed by friction of the stream, eddying, etc. Since the vane of Fig. 2 is less efficient than Fig. 1, the stream carries away a certain amount of energy in the shape of velocity, and as before stated, where there is single impact such terminal energy is lost. But if the stream be made to strike a second vane, a greater or less fraction of its terminal energy is absorbed, and a third and a fourth impact may be arranged, so that almost any desired total of the initial energy of the jet may be usefully abstracted, the limit being that at which the friction and eddy loss of an additional vane equals, or exceeds, the gain otherwise derived.

By the same general method of reasoning it may be seen that if we slow down the velocity of a turbine, and thus render its blades less efficient than when run at the speed of maximum efficiency for individual blades, multiplying the latter to secure additional impacts regains the total value of energy absorbed, and this is the vital principle, which enables steam turbines to be run at moderate speeds. Single impact turbines now regularly on the market run as high as 30,000 revolutions per minute, being geared down to a driving shaft to about 3000, while multi-impact motors, such as are largely coming into use for electric drives, are run at some 3600 revolutions direct, and the marine type installed in vessels abroad are run at much less speed.

The design of a multi-impact water turbine is a comparatively simple matter, but for steam the elastic quality of the fluid renders the calculations extremely complicated. The passages must be so formed as to allow the steam to expand to just the extent that would give out to a piston the energy absorbed by the impact and friction against the actual turbine blade. This must be done step by step so that there is a perfectly smooth flow and consistent expansion, as otherwise eddying and "free expansion" would take place and a heavy percentage of the available energy of the fluid be wasted.

In any turbine, the less the efficiency of a single blade, the greater must be the number of blades and the greater will be the loss by friction of the fluid over the surfaces, although such friction is far less than is supposed, the effects of eddying and sudden enlargements of passages being often attributed to friction, in the same loose way in which "cylinder condensation" is the "official scapegoat," on the back of which so conveniently rests the unsatisfactory work of some reciprocating engine designers. Multi-impact steam turbines are usually made either of the radial, or of the parallel-flow type. In the radial flow motor, Fig. 3, the steam enters at either the centre or the periphery and flows on approximately radial lines between sets of blades alternating on adjacent disks. If one set of disks and their blades are stationary, such are called "guide disks" and "blades," while the moving elements are the "drive disks" and "drive blades."

In the "parallel flow" turbines, Fig. 4, steam flows longitudinally, or axially, through sets of blades carried on cylinders or drums, and here there may be guide and drive members, or both sets may revolve. In the turbine most extensively employed at this time for electric driving, the drive

blades are fastened to an inner barrel or shaft while the guide blades are secured to the outer casing. In some turbines where a great number of impacts are desired with moderate length of motor, there are a number of drive disks keyed to a shaft and a number of alternating guide disks secured to or

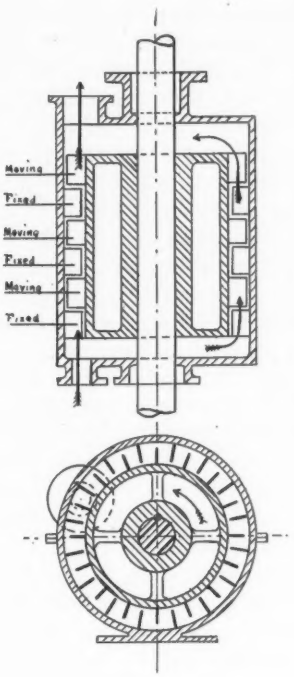



Fig. 4.

forming part of the casing, and such disks are composed of inner and outer rings having blades between the rings forming the walls of passages through which the steam flows amongst the blades. The fluid flows along one such passage, then is directed back through the next passage, the blades in which are set at the reverse angle to those in the first passage, and after completing the second journey, it is again returned along a third annular space and so on, until its energy has been absorbed, when it is exhausted to the condenser or elsewhere.

In the radial flow turbine the steam, after acting on all the sets of blades of one disk, is guided to a second disk and so on to the necessary number. As the blades of the turbine must clear the opposite disk surface for the radial type, and as there must be some clearance in all types to prevent "seizing fast" under unequal expansion, it follows that there will always be more or less leakage of steam, and there are also losses of heat through radiation and conduction. But in actual practice there is far less loss through these causes than in the ordinary reciprocating engine, and as the theoretical energy that may be had from a given weight of steam is the same for both types of motor, the turbine has shown itself the most economical consumer of coal, while in repairs its cost is insignificant.

If the guide blades of a turbine are designed to revolve in the opposite direction to the motion of the drive elements, the turbine's speed may be reduced to one-half, since it is the relative motion of the two sets of blades that determines the power, and a number of such double acting motors have been proposed.

## STEAM AND OIL SEPARATORS.

### Different Methods of Separation Employed in the Standard Types of Separators.

PART I.

Steam is usually found to exist in one of three states; dry saturated, wet saturated and superheated. Saturated steam is the kind of steam that is always given off when the steam leaves the surface of the water, and remains saturated so long as there is any water in the vicinity of it or no heat is added to it. By dry saturated steam is meant steam without any particles of water being held in mechanical suspension. Ordinary or wet saturated steam has suspended in it minute particles of water and is the kind that exists generally in steam boilers and steam pipes. Superheated steam is produced by taking saturated steam and adding heat to it, so that its temperature will be higher than that corresponding to the pressure at which it was generated.

If steam was given off from a boiler in a dry state, or was superheated before it entered the engine, there would not be any use for steam separators, but this is usually not the case. Steam seldom comes from the boiler dry and in ordinary plants it is seldom superheated, so that the steam actually used in most plants consists of a mixture of dry steam and water, the proportions varying, depending on the kind of boiler and the degree to which it is forced. Steam seldom comes from a boiler with less than 3 per cent. or 4 per cent. entrained water, while under bad conditions it frequently contains 15 per cent. or 20 per cent. and sometimes more. The reason for this is not difficult to understand, when the surface of water is examined in a boiling state. The bubbles of steam rising to the surface break through the surface of the water with considerable violence and throw a fine spray into the steam

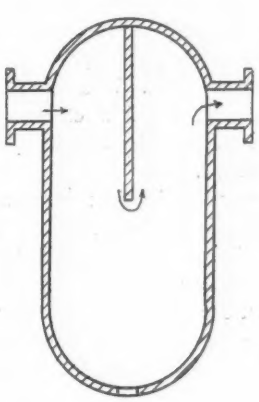


Fig. 1.

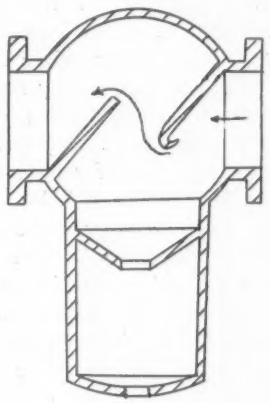


Fig. 2.

chamber. The steam space being filled with this mixture, the spray is carried along by the velocity of the steam into the piping. The more the steam generators are forced, the faster will be the ebullition, and the more moisture or water will the steam contain. In modern water tube boilers, which have small steam space, small liberating surface, small volume of water and rapid circulation, the amount of water in the steam is very great and for this reason many of these boilers contain within themselves separating and superheating devices.

Condensation of the steam on its way to the boiler is another cause of wet steam. This amount is considerable,

especially when the pipes are not protected with some covering and is not negligible when they are covered, although the saving is considerable.

The effects of the presence of water in steam are very serious, especially in large amounts. The most serious effect of water in the steam is the loss of efficiency. Every particle

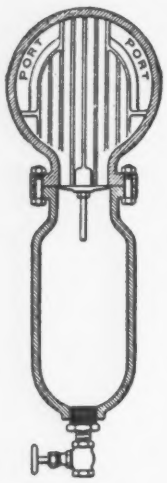



Fig. 3.

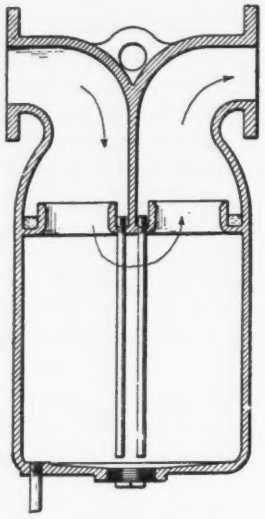


Fig. 4.

of water that is carried along with the steam from the boiler represents that much lost heat. When it reaches the engine, its effect is equally detrimental. One of the principal losses in the cylinder of a steam engine is the loss due to initial condensation. This is very much aggravated when the steam is wet, owing to the fact that the wet steam more readily gives up its heat to the cool walls of the cylinder at the beginning of each stroke. It is also well known that wet steam causes valves, pistons, piston rods, cylinders and packing to deteriorate and wear out more rapidly than dry steam. The effect of wet steam in the steam turbine is to cut down its efficiency and wear out the blades. Dry and superheated steam in this type of engine are used for these reasons.

The fact that water is incompressible is often demonstrated in the clearest manner by the evil effects of water in the steam. Broken cylinder heads, bent rods and cracked pedestals are among the accidents which are likely to result from allowing the mechanical clearance between the piston and cylinder head to become full of water, not to mention other more serious results. The danger to the piping is equally serious particularly when the steam moves with a high velocity. The steam being elastic does not affect the piping but the water when its direction is changed hits the outward portion of the pipe such a hammer blow, due to its inertia, as to often result disastrously.

The principal method of removing the entrained water from the steam is done mechanically by a separator. Steam separators are divided into two classes, those that depend upon the centrifugal force or inertia for separating the water from the steam, and those that depend upon baffle plates and deflectors for collecting the moisture. Each of these really depends on the other. The tendency of any body when in motion is to move along a straight line until it is acted upon by some external force. As water is heavier than the surrounding steam, its inertia is greater, as is also its centrifugal force, when its direction is changed. In the case of baffle plates, steam changes its direction while the water continues to move in a straight line until deposited upon the surface, which is then caught and carried out of the way of the on-rushing steam.

The first steam separator was used by Dr. Haycraft in 1830 and consisted of a baffle plate, which was placed in the direct path of the steam, and receiver below to catch the water, as shown in Fig. 1. This form of separator is open to two objections. In the first place, the water is dashed into a finer spray when it strikes the plate and becomes more intimately mixed with the steam, and, in the second place, that water which runs down to the bottom of the plate is easily picked up again by the on-flowing steam and carried into the pipe beyond. Dr. Haycraft later modified this form by making numerous changes, but they more or less all possessed these same faults. Modern separators have overcome these difficulties, the object of all of them being to so catch the water when it is separated that it cannot be attracted to the steam again. This is done by either using baffle plates of peculiar construction, using the effect of centrifugal force combined with baffle plates, or by using the effect of centrifugal force alone. A number of the most widely-known separators exemplifying each of the above-mentioned principles are described in this article.

A modification of Dr. Haycraft's separator is illustrated by the Gardner separator shown in Fig. 2, which makes use of two baffle plates inclined at an angle of forty-five degrees. The steam first strikes the baffle plate with the ridge at the bottom, which tends to hold the water from curving around with the steam. What water is not caught at this first plate is made to strike the second, which, due to its inclined position, prevents the water from flowing in the direction of the steam, but drains downward to the chamber below. The receiver is separated from the steam chamber by a conical shaped diaphragm.

A type of separator which successfully employs only one baffle plate is the Cochrane separator shown in Fig. 3. The single baffle plate faces the inlet opening so that the entering

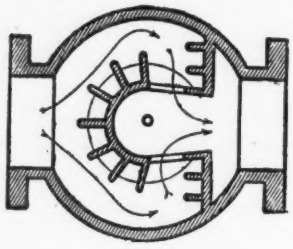


Fig. 5.

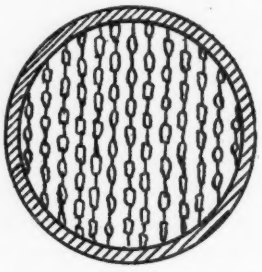


Fig. 6.

steam strikes it in the centre. The baffle plate is ribbed vertically so as to prevent the side travel of the separated liquid. The ports are placed at the sides so that the steam passes in an undulating manner across the plate, turns at right angles to go through the port openings, again turns at right angles across the other side of the plate and again at right angles to go out of the exit pipe. The water runs down the plate to the well below, which is sealed on the exit side of the separator so that no water can be picked up again, the moisture on that side of the separator being led to the well by a pipe.

The Hoppes separator is shown in Fig. 4. It makes use of no baffle plates other than the dividing partition between

the inlet and exit pipes. It depends upon the interception of the entrained water by gutters which are kept partially filled with water and is designed so that the steam can flow in either direction. Both the inlet and outlet pipes are surrounded by these gutters partly filled with water which intercept all entrainment following the surface, while the downward plunge of the steam enters the steam chamber and throws the water to the bottom of the separator. The excess water is

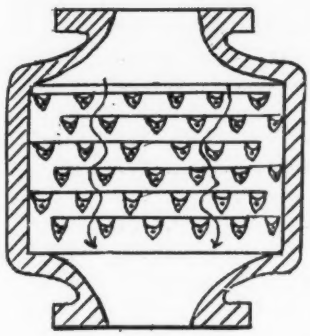


Fig. 7.

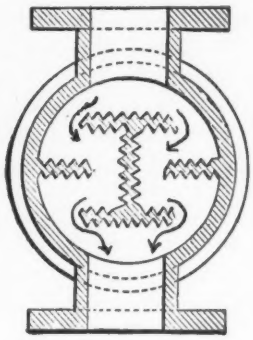


Fig. 8.

carried from the gutters by pipes to the bottom of the separator from which it is trapped in the usual manner.

The Baum separator, a horizontal section of which is shown in Fig. 5, makes use of a number of radial baffle plates against which the entering steam must strike. These ribbed surfaces are made radial so that the water in the steam will not splash back into the steam current. The steam is then divided into two channels which are continued to the outlet. The water adheres to the ribbed surfaces which run down to the receiver below, carrying the water out of the way of the steam. The steam goes through two ports, the plane of which is at right angles to the steam current. Any moisture that is left in the steam is at this juncture thrown against the baffle plates which run across the receiver and which separate the water chamber from the outlet to the steam. This prevents the purified steam from picking up the separated water.

The Utility separator, shown in Fig. 6, makes use of a number of chains instead of baffle plates. In this separator the direction of the steam is not changed but the small particles of water and oil are enmeshed with the chains and the action of gravity draws them to a receiver at the bottom. The chains are numerous enough so that if a particle of water be drawn away from one chain it will immediately strike another and adhere to it until by the time the last chains are passed the steam has given up all of its entrained moisture.

The process of extraction of the water and oil in the steam in a Bundy separator is shown in Fig. 7. A series of separating plates, six or more in number, are placed in a vertical position in the body of the separator through which the steam must pass. These plates consist of upright hollow columns with openings at regular intervals for the admission of the water and oil to the central duct which drains downward to the receiver. The columns in these plates are set staggered. The steam takes a zigzag course and as it passes around these intercepting columns the water and oil are caught and drained away. The plates are flanged at the bottom to form a barrier between the body of the separator and the receiver, which prevents the picking up of the water and oil in the receiver and carrying the same forward into the steam pipe. Since this type depends on the force of gravity, it can only be used horizontally.

The Wyoming separator is shown in Fig. 8. It consists of a series of serrated baffle plates around which the steam is made to pass, against which the steam impinges and down which the moisture trickles to the vessel below. This separator is usually connected to an automatic trap below, which not only takes care of the natural condensation but in the event of large quantities of water entering the separator, the discharged valve is so arranged as to take care of it. It likewise can only be used on a horizontal pipe.

The Lowden separator, shown in Fig. 9, is very similar to the Utility, except that it uses plates instead of chains to catch the water. The steam in its passage through the separator is intercepted by a series of catch plates which have holes through them alternating each other. Around these holes are collars, or ribs, and between the collars are vertical strips, the object of both being to prevent the water being carried along with the steam. The water gravitates to the bottom into a receiver from which it is trapped.

The Stratton separator is based on the principle that, if a rotative motion is imparted to the steam, all the liquid particles it may contain, being heavier than the steam, acquire centrifugal force and are projected to the outside of the current. The separator shown in Fig. 10 consists of a vertical cylinder with an internal central pipe extending from top downword, for about half the height of the apparatus, leaving an annular space between the two. The current of steam on entering is deflected by a curved partition and thrown tangentially to the annular space at the side near the top of the apparatus. It is thus whirled around with the velocity of the inflowing steam,

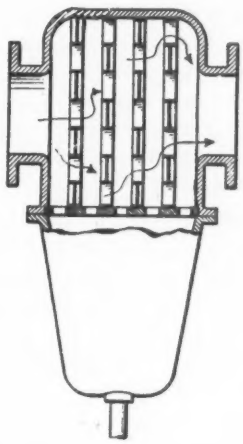


Fig. 9.

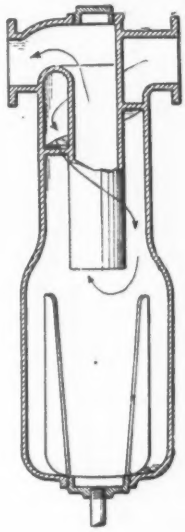


Fig. 10.

producing the centrifugal action which throws the particles of water against the outside cylinder. These adhere to the surface so that the water runs down into the receptacle below, while the steam following in a spiral course to the bottom of the internal pipe abruptly enters it and passes upward and out of the separators. As the rapid rotation of the current of steam also imparts to the separated water a whirling motion, which tends to interfere with the proper discharge of the ap-

paratus, the separator is provided with wings or ribs projecting inwardly at an acute angle to the course of the current, thus breaking up this whirling motion, and allows the water to settle quietly at the bottom from whence it passes off through the drain pipe.

### Gas Power Applied to the Textile Industry.

A paper with the above title was recently read by B. H. Thwaite, of Westminster, England, before the New England Cotton Manufacturers' Association. In it he says that some years ago he carried out a series of experiments in making investigations into the question of generating motive power by direct combustion and in those investigations almost every available fuel was employed, ranging from wood, charcoal, peat, coke and anthracite and bituminous coal and he found that all these fuels are available for producing motive power gas. The chief result of these experiments has been, however, to prove that the harnessing of the waste gases from blast furnaces to gas engines is very economical and above possible competition by the steam engine, whether rotative or reciprocating.

The success attending the employment of these waste gases was followed by an increase in the power units of internal combustion engines and to-day single unit quadruple cylinder engines of 3000 indicated horse power are available for the power user. One of the results of his investigations proved the fact that by the physical compression of the explosive mixture, a combustible gas of almost any thermal value above 50 British heat units per cubic foot can be employed in a gas engine. He also realized that if the density of the poor combustible was increased by physical compression to a certain degree, the sluggish inflammability of the gas would disappear and the gas and air would ignite with sufficient rapidity and certainty of effect to satisfy internal combustion engine working requirements. This fact after it had been demonstrated brought into the field of usefulness, the enormous volumes of waste gases that flow into and pollute the atmosphere at every iron making centre, and in the United States alone the potential power of the furnace gases from American furnaces is counted in hundreds of thousands of horse power.

To meet the demand for engines to convert the awful waste of power, many eminent engineers on the continent of Europe have for several years been applying almost their entire attention in designing engines to secure all the qualifications that a steam user and electric supply consumer must have, and in Germany alone it is said that over 50,000 horse power of large capacity gas engines are in active service.

Mr. Thwaite then says that assuming all other conditions to be equal, it should be obvious that the direct combustion or oxidation of fuel behind a piston, which is pushed forward by the expansion of gases as the effect of such combustion, must of necessity be more thermally economical than the steam power system ever can be and it is no wonder when it is remembered that the solid fuel is indirectly or wastefully burnt, generally at atmospheric pressure in a steam boiler, the steam thus produced sustaining in addition a thermal loss by condensation between the boiler and the steam engine cylinder. While a steam engine gives an every day 10 to 12 per cent. efficiency, he says that a well designed gas producer and gas engine will give a combined advantage of at least twice that of steam power plant and this result is obtained in every day running work, and not merely in tests in which every possible condition is assured to produce the best thermal results. A gas engine should develop an indicated horse power hour for a carbon consumption of 0.75 pounds, whereas no reciprocating engine under ordinary working will secure this time energy of one horse power hour for a less expenditure than 1¾ pounds of carbon.

He then gives the results of a test made with a power gas plant driving a textile factory as follows:

| | |
|---|---|
| Diameter of cylinders | 16″ |
| Length of stroke | 24″ |
| Revolutions per minute | 140 |
| Explosions per minute | 140 |
| Mean initial pressure—pounds | 297 |
| Mean effective pressure—pounds | 78 |
| Indicated horse power | 133 |
| Producer gas per hour | 10,640 |
| Coke used per I. H. P. per hour—pounds | 0.99 |
| Actual carbon used after deducting 15 per cent. of ash—pounds | 0.84 |

Outside the question of thermal efficiency, Mr. Thwaite says that here is a duty for all of us, and one that has hitherto been altogether neglected, but which it is a crime against natural laws to overlook and this consists in preventing, as far as it is possible, the smoke pollution of the atmosphere, a product of imperfect combustion. One of the greatest disadvantages associated with steam power is the fact that it is responsible for the major part of the atmospheric pollution, which is proceeding day and night throughout the manufacturing centres. The more or less complete removal of this is one of the advantages that can be claimed for gas power.

### Electricity for Thawing Water Pipes.

One of the newest sources of revenue of the electric power and traction companies in the Northern cities of the United States and in Canada is the thawing of ice in water pipes by means of electric heat. The past winter, which, as everyone knows, has been especially severe in all sections of the country, has brought the new system of pipe thawing into special prominence. One of the most successful and extensively applied systems was that used by the Montreal Light, Heat and Power Company. Notwithstanding the fact that service and water mains in Montreal; owing to the necessity of protection during the very severe winters prevalent there, are buried seven and eight feet deep, there were occasions during the past winter when 8-inch mains at this depth were frozen solid, and nearly 1000 frozen service pipes were reported to the water department during the past winter. The electrical system is effective, economical and rapid. A transformer is placed in a sleigh and driven to the point of trouble. Reels of wire, mounted on turntables, to facilitate the paying out of the wire in any desired direction, are also provided. The lighting service wires on the street are connected to the primary of the transformer and the secondaries of the transformer directly to the pipe to be thawed. This gives a low voltage and large current in the pipe, developing an amount of heat that may be readily controlled and applied to any particular section of pipe by simply making wire connections therewith. One such outfit thawed from 15 to 30 pipes a day, this being accomplished in from six to twenty

minutes. The 8-inch pipe referred to above was 700 feet in length, and required the application of 1000 amperes for forty minutes. The average cost of the house service has been about $1.50 in each case, compared with a cost of $30.00 to $40.00 incurred where excavation had to be done when other than the electrical method is used. At Sault Ste. Marie considerable work of the same character has been done for a number of years past, the average time for thawing ⅝-inch or ¾-inch service pipes being about ten minutes, for which a flat rate of $5.00 is made. Similar work was done during the past winter in some of Philadelphia's suburbs and neighboring cities.

### Instructions for the Care of a Dynamo.

Keep the machine clean and when not running keep covered.

Do not run a machine when the brushes are not properly set.

Do not close the switch before the brushes are on the commutator.

Remember that trouble with the brushes is a sure sign of carelessness or poor attention.

Run the generator at a proper speed and at a constant speed. Trouble with unsteady lights can always be expected if driving power is unsteady.

Do not expect the same results with a machine overloaded as when operating under normal load.

Do not use poor oil unless you want heated bearings.

Do not run a belt any tighter than necessary to carry the load at steady speed.

Do not use emery cloth on the commutator or collector rings, or on the bearings, as the grit sticks to the surface and will make trouble. If necessary to lubricate the commutator use vaseline on a piece of canvas.

Do not use a fuzzy cloth or cotton waste in applying lubrication.

### Location of Feed Pipes in Steam Boilers.

By W. F. Burdick.

Having had some experience with feed pipes that were not satisfactory and having found ways to remedy the resulting evil, a description of them should prove interesting to other engineers who are travelling in the same way. One of these was a vertical boiler which was fitted with a feed pipe that entered the water leg about 2 inches from the bottom of the boiler. It was simply connected into the shell and as the feed water was discharged, the stream of water struck the inner plate of the water leg. No heater was used in this case but a good injector heated the water to about 120 degrees Fahr. in the winter season. As the pressure was 100 pounds per square inch, the feed water was much cooler than the water in the boiler, which resulted in uneven contraction of the inner plate.

In the ash pit there was a spot which plainly showed that the plate was corroded, for this was on a lower level than the grate. The remedy which was applied is shown in Fig. 1. A hole was cut in the boiler head and tapped for 1½" pipe. It was placed directly in line with the inner and outside sheets. A long 1" pipe was placed through this hole, as at A, the pipe being capped on one end. For about 6 inches from this end several small holes were drilled to allow the water to spray, as at B. On the other end was cut a long thread and a 1½" bushing was made, the thread being cut in the opposite way from which bushings are generally made. This thread projects through the bushing far enough to allow one of the two lock nuts to jam on the bushing and the other on the globe valve. This prevents the thread from leaking. From the bushing the pipe went to the injector in the usual way.

The effect of this change was a great advantage to the boiler, as the water left the injector at about 120 degrees Fahr. and travelled through the steam and hot water in the boiler, discharging about 6" from the bottom through the small holes in the end of the pipe. This raised the temperature of the feed water considerably before it was discharged directly into the

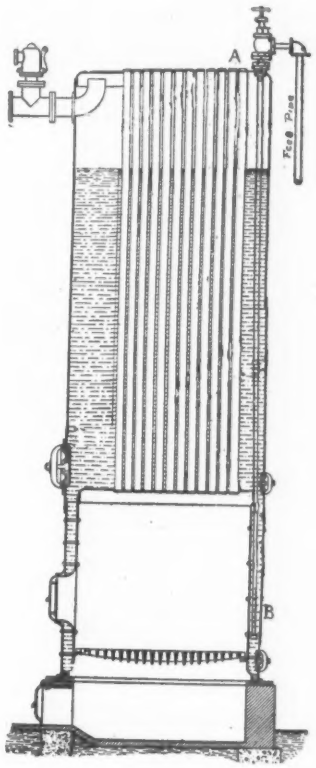



Fig. 1.

boiler. The result of this change was that corrosion disappeared entirely and the stay bolts, that leaked occasionally, stopped leaking entirely and for years the boiler has not given any trouble as regards leaks caused by the water being directly discharged on the fire sheet.

There is another vertical boiler which is very common in the Eastern States, which is called the Manning boiler. It is constructed the same as any vertical fire tube boiler with the exception that the firebox is somewhat larger than the upper portion, as shown in Fig. 2. This boiler has a perforated pipe running through it from shell to shell and is located about one-half way between the crown sheet and lower gauge cock. The feed pipe may be attached to either end of it. In most of the plants where these boilers are employed, the feed water

is discharged through the perforated pipe. The writer has had some experience recently with this type of boiler and finds it very injurious to discharge feed water above the crown sheet because there is a regular forest of tubes around and very close to the feed pipe. With this arrangement, it is almost impossible for the sediment or foreign matter to find its way down to the blow-off, but it will lodge on the crown sheet between the tubes.

In a plant where the exhaust steam from the engines and pumps is used for heating and other purposes, and the condensation pumped back into the boiler, it is impossible to keep the grease from collecting on the crown sheet, as this water contains cylinder oil and even if separators are used, some grease will find its way there and it will not be there very long before the tubes will leak. It is always a difficult matter to stop them, even if great care is taken, as the grease is still

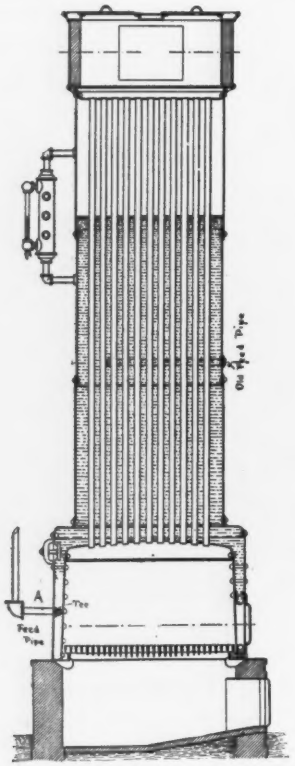



Fig. 2.

between the tubes and crown sheet, which will not allow them to take up iron to iron, when expanded. The proper way for the feed to be placed in these boilers is shown at A, Fig. 2. A hole is tapped in the outside sheet close to one of the hand holes and in the centre of the plate between stay bolts. Cut the hole on the opposite side from blow-off if convenient. Screw in a nipple with a thread long enough to project through the shell into the water space so that the nipple can be screwed into a tee held inside the boiler and if care is taken, the tee can be caught on the nipple as soon as the first thread projects through the shell. This is an ideal way to feed this style of boiler, for the sediment and grease will stay in the bottom and by opening the blow-off occasionally it will to a certain extent be blown out. The tee being placed in the leg protects the fire sheet from being struck directly by the feed water when entering.

**Recent German High-power Electric Mining Hoists.**

Until recently, the main hoisting engines in the largest mines were operated exclusively by steam power, but during the past two years a number of high-power electric mining hoists have been installed, operated by elctric motors of several thousand horse power. These modern electric hoists have a capacity ranging as high as 11,500 pounds and designed for hoisting materials from a depth of from 800 to 3000 feet, both direct and alternating current motors being employed, the former operating at a pressure of 500 volts and the latter at pressures from 1000 volts to 5000 volts.

The illustration on front cover shows a direct current mining hoist and the accompanying illustration shows a motor generator with a 40-ton fly wheel for operation and connection with the same installed at Merklinde, Germany. This electric mining hoist has 2 electric motors each having a maximum output of 1400 H. P. directly coupled to a main axle of a driving pulley or drum designed to raise a load of 9240 pounds, made up of 6 trucks of 1540 pounds each, lifting the same from a depth of 1625 feet with a speed of from 35 to 70 feet per second. This installation was originally designed to be operated in connection with storage batteries as regulators, to be connected in various groups according to the load and speed. The two direct current motors on each side of the hoisting drum were designed to be connected in series or in parallel so that the maximum hoisting speed could be either 35 or 70 feet per second. This equipment was designed and constructed by Siemens & Halske, of Berlin. The Siemens-Schuckert works have recently installed at this plant a particularly interesting motor generator outfit for use in connection with this enormous electric hoist either without the storage battery or in connection with the same.

The electric hoists operate at a depth of 942 feet and at a speed of from 35 to 40 feet per second at the present time instead of 70 feet per second, the motors being connected in series. Later it is intended to hoist the materials from a depth of 1625 feet. At the present time the hoist is working at loads as high as 10,350 pounds, with a daily capacity of 1000 tons.

The motor generator recently installed consists of a 300 H. P. direct current motor which operates at a pressure of 500 volts, driving a direct current dynamo at a speed of 350 revolutions per minute. Between the motor and the generator is an enormous fly wheel 13 feet in diameter and weighing 40 tons, that has a peripheral velocity of 240 feet per second. The motor operates at a constant current of about 400 amperes while the generator supplies a very heavy current reaching as high as 2000 amperes.

When the storage battery is employed, the exciting current of the motor magnet is altered by switching in the storage battery cells gradually so that the speeds may be varied to 7, 14, 21, 28 or 35 feet per second. The storage battery is connected in four groups and the voltage may be applied gradually by connecting in these groups step by step, also by using resistances between the groups.

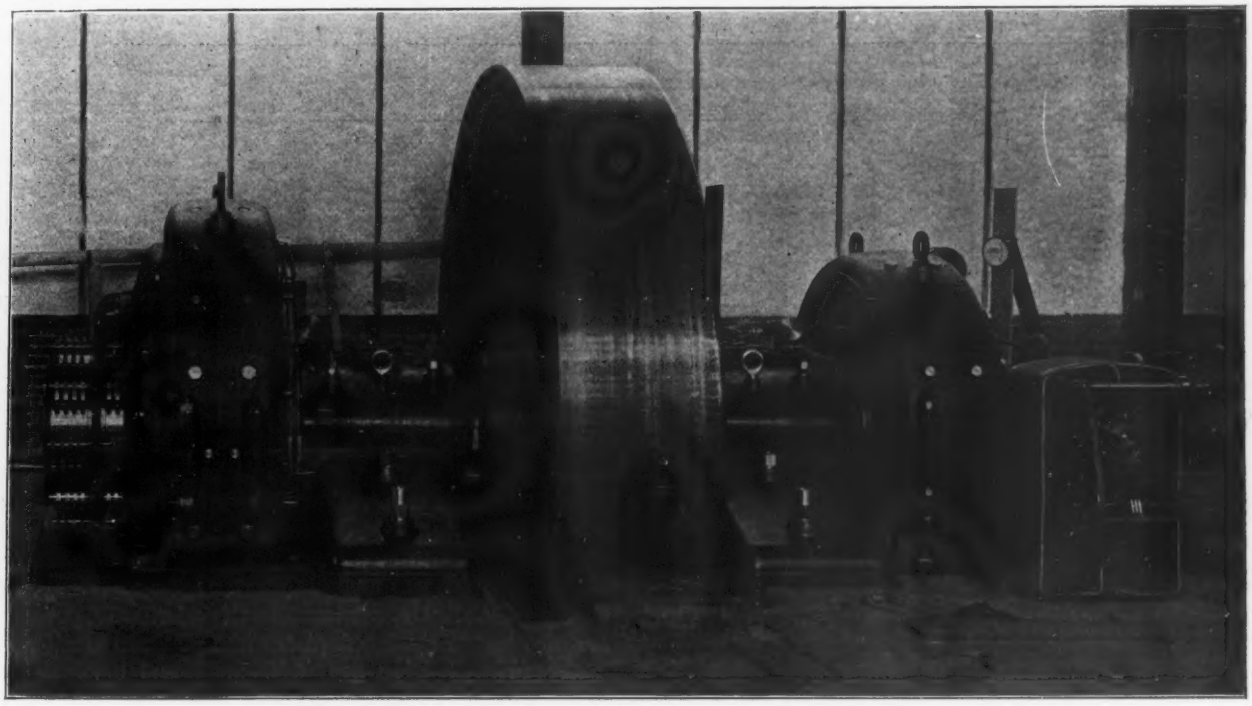
The driving pulley is utilized in this installation, the hoisting rope passing but once around the pulley, which system is best adapted for hoisting from one level only. The depth indicator is located in front of the hoisting machine and is readily seen by the driver, so that he can know the exact position of the

cage in the shaft at any instant. A safety device is provided which prevents maximum speed from being exceeded and makes it impossible for the cage to approach the end of travel without a proper gradual decrease in speed, and if the speed at any point exceeds a certain fixed maximum the current is automatically shut off and a break applied. The current is generated in a power house directly at the mine but where the power house is located at a considerable distance, a 3-phase alternating current is usually employed.

The power plant is located ¼ mile from another mine, which has a total depth of 350 meters. The electric mining hoist at this shaft utilizes two trucks having a capacity of 2750 pounds. At this plant the hourly capacity is 60 tons and the speed of the electric hoist is 26 feet per second. One electric motor is utilized in this case operating at 1000 volts pressure supplied from the transmission line.

pounds and the hourly rate of working of the hoisting plant being 50 tons. In some instances the electric power plant is located several miles from the mining shaft and voltages are required much higher than in the cases just mentioned. At Eisleben, the power house is located 4 miles from the shaft and the current, which is of the 3-phase type, has a pressure of 3000 volts. The electric hoist at this mine is operated by two motors, the present speed of the hoist being 20 feet per second, the depth of the shaft being 1050 feet, but later the speed will be increased to 40 feet per second, when the hoist is required to be operated at a depth of 1870 feet. The present capacity is 4800 pounds, the hourly output being 95 tons.

The power plant at Karnap, near Essen, is located 6 miles away from the mine, and the 3-phase alternating current supplied by generators driven at this station by steam engines is transmitted to the electric hoists at a pressure of 5000 volts.



Motor-Generator with 40 Ton Flywheel, for use with German Direct Current Mining Hoist at Merklinde.

At this plant the power house is equipped with gas engines driving the 3-phase alternators, while at the power house at Friedrichshall, water power is utilized, the station being located ¾ mile distant. The electric hoist at this mine operates at a depth of 600 feet and the electric motor which is directly coupled to the hoist is supplied with a 3-phase alternating current from the power house at a pressure of 2000 volts. This hoist operates at a speed of 23 feet per second, 2 trucks being utilized with a capacity of 3100 pounds, the hourly capacity of the plant being 77 tons.

At Bresslau, the same voltage is employed as well as the 3-phase alternating current but the power house is equipped with steam engines instead of hydraulic turbines as in the former instance. The present depth at which the electric hoist operates in this mine is 625 feet, but later 1100 feet will be the maximum depth while the speed is 17 feet per second. Two trucks are employed, the hoisting capacity being 3300

At two of these shafts the electric hoists operated by two motors have a speed of 45 feet per second. The motors are of the 3-phase type and are directly coupled to a driving pulley of the Koeppe system, the capacity of the hoisting apparatus being 100 tons per hour, 8 trucks being used of 10,560 pounds. The present depth at which this mine hoist operates is 1600 feet, but later it will operate at the depth of 2500 feet.

One of the largest electrically operated hoists which is installed at Hann, has an hourly capacity of 175 tons. The electric motors are directly coupled to the driving pulley and are supplied with an alternating current of a 3-phase type from a steam driven power station at the mine, the alternators of which supply a current of 3000 volts. This mine is very deep, the hoist operating at the present time at a maximum speed of 60 feet per second and to a depth of 2400 feet; later it is expected the hoist will work at a depth of 3000 feet, lifting 8 trucks weighing 11,440 pounds.

# The Practical Engineer

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## The Heating Value of Coal.

The heat that is contained in one pound of coal is apparently an easy quantity to obtain, but the fact is, it is a difficult matter to get at exactly. To be sure, it can be obtained by making a chemical analysis, or it can be obtained by burning it in a calorimeter or it can be obtained by actual burning it under a steam boiler but in each case the result obtained is different. A chemical analysis can be made in two ways: ultimate and proximate. In the ultimate analysis, the coal is divided into its elements of carbon, hydrogen, oxygen, nitrogen, sulphur, ash and moisture, from which calculations are made based on the heating value of each element, giving a result which apparently should give the correct value. Another chemical analysis, which is far easier made, is the proximate analysis which gives the amount of moisture, fixed carbon, volatile matter, ash and sulphur in each pound of coal from which according to empirical formula the heating value can be calculated.

A laboratory method for finding the heating value of one pound of coal that is generally adopted is by means of a calorimeter. This apparatus usually burns the coal under water in the presence of an excess of oxygen, the resultant heat of which is given to the surrounding water; the amount of water and temperature being known, the heating value of the coal can be calculated, which gives a value quite different from that calculated from the chemical analysis. The practical method for finding the heating value of one pound of coal is by burning it under the boiler. The heat from one pound of coal is capable of evaporating a certain amount of water, but in practice it evaporates much less than this amount, because a certain proportion of the heat must go up the chimney to give the proper draft and some heat is lost in the ash pit and some by radiation. Here again is another heating value of the coal which differs from the preceding values obtained.

It can easily be seen why the latter value obtained in practice is less or different from the other values, as there may be imperfect combustion of the carbon, which produces carbonic oxide and gives out less than one-third of the heat which is yielded by complete combustion, as well as other numerous and variable wastes. What this value does give is the highest practical heating value, if the conditions of grate bars, draft, extent of heating surface, method of firing, etc., are the best possible for the particular coal tested and it may give results far below its true practical heating value if these conditions are unsuitable to the coal.

With the chemical and calorimeter methods, the accuracy of the results would seem to depend upon the care and skill of the operator and the method of analysis and kind of calorimeter used, but with all the degree of care which is taken to procure accurate results, the heating value derived from each of these two methods differs and in some cases, differs widely. There were made recently in one of the laboratories of a large college, a series of tests to determine upon some law by means of which, if the chemical analysis were known, the calorific value could be determined, but a number of curious results were obtained. It was found that two coals having exactly the same chemical analysis had a widely different calorific value and two coals which had a different chemical analysis were found to have nearly the same calorific value. Of course, doubt might be cast upon the accuracy of the calorimeter, but when a dozen different tests of the same coal give the same value and a number of tests of another coal, each give approximately the same value for it, the discrepancy must be looked for elsewhere. It seems that the best calorimeter which was used in these tests was an arrangement known as the bomb calorimeter. In this calorimeter, powdered coal of a known amount is placed in a platinum crucible not far from two electric wires which are joined together by a very soft piece of fusible wire. The whole apparatus is then closed and the bomb, as it is called, is put under a known amount of water. Oxygen under pressure is then forced into the bomb in excess of the amount required and an electrical circuit is made through the soft fusible wire. This wire, heated by the electricity, drops down into the powdered coal which is ignited and burned, the conditions being such that the coal explodes with great force, insuring complete combustion. This heats the surrounding water and by proper calculations, the heating value of the fuel can be obtained.

The value of knowing the exact heating value of the coal is of importance to the engineer because the efficiency of a boiler cannot be accurately obtained unless it is known. Efficiency in this case, as in all others, is the ratio of amount of heat used by the boiler, to the amount given out by it. In many boiler tests, great care is exercised in finding the amount of heat absorbed by the boiler and very little care taken as to the amount capable of being generated by the coal, this value often being assumed.

Since it is desirable that the true heating value of one pound

of coal be known, it would be a direct step in the advance of progress if some apparatus that could be used in the boiler room were designed to give this value. As it is, at the present time, a boiler test, if made for efficiency, involves the aid of the chemical laboratory and takes from the engineer, unless he be a chemist, a part of the test which should be under his direct supervision.

**The Use of Steel for Steam Pipes.**

One of the most important parts of a steam plant, especially since the steam units have increased so very rapidly in size, is the piping. This fact is brought to mind by the occurrence of several accidents to steam pipes which have recently happened in large steam plants. The steam pipes of a 3000 H. P. plant are slightly larger in diameter than one's finger and when they break, nobody is required to run and tell you that fact if you are within a radius of several miles. The results of the damage done are often confined to the pipe itself but very often the escaping steam does damage to the engines and buildings and the sudden release of pressure is likely to injure the boiler. This is one of the reasons why moderate sized power houses are often preferred to very large ones and it is certainly true that in the matter of immunity from accident, two or three good sized stations are better than one enormous one.

Whenever any accident happens, which is always unexpected and from some unforeseen cause, there are usually a number of explanations given why it happened. Among the causes of several accidents to steam pipes which happened lately, the use of steel in the pipe has been blamed for its breakdown.

Of the three kinds of iron with which an engineer has to deal, wrought iron is the "Old Faithful," especially when used in welded pipes. Steel has a higher tensile strength and very often the same percentage of ductility but there seems to be something in the manufacture of the pipe that always casts a shadow of a doubt about a welded steel pipe. The manufacture of both kinds of pipes is precisely the same except that wrought iron skelp, from which the pipes are made, is more juicy than the steel skelp. It is this particular quality that makes wrought iron so easily welded and so very reliable, as a good weld is often stronger than the material surrounding it. When steel is welded, instead of melting together and forming one homogeneous mass, the particles of iron in the two adjacent pieces seem to be driven into each other rather than adhering of their own free will. When a lap welded joint of steel is pulled apart on the testing machine, and the joint fails under tension, the surfaces that were welded invariably pull apart and show a more or less smooth surface, indicating what in wrought iron would be classed as an imperfect weld.

The main reason why steel pipes are manufactured is the lower price of the skelp from which they are made. The largest steel corporation in this country a few years ago flooded the markets with steel pipe principally on this account and the fact that independent mills had purchased all the wrought iron skelp available. The unreliability of steel pipe is also shown at the pipe mill where it is manufactured. At one mill in particular, the record of using steel skelp showed a falling off in output of 25 per cent. and an increase of waste of at least 20 per cent. when steel was used.

The unfortunate part of the presence of steel pipe in the market is the fact that a purchaser cannot tell by observation or even by testing whether the pipe is made of wrought iron and steel. Some engineers can sometimes tell when they cut a thread on the end by the appearance of the chips as they come from the die. There should be no objection to a person receiving steel pipe if he specifies steel pipe in making the purchase, but the engineer whose steam pipe bursts is usually the one to suffer when steel pipe is unjustly sold instead of wrought iron.

There is also another property of the metals which is a peculiar one and which is sometimes called "fatigue." It is the property of a metal for standing during a long period of time, a number of vibrations when under stress. A steel weld may apparently stand all the tests when first used but when used on a vibrating steam pipe under a pressure of 175 pounds per square inch it becomes "fatigued" and when an unusual vibration, such as water hammer, strikes it, it is very apt to give way. While most of this discussion applies both to large and small pipes, it is the large steam pipes which are especially referred to, as the factor of safety in a small pipe is so large that while the same conditions do exist, the pipe is not put to the test as it would be in a larger one.

**Two Engineers Necessary.**

The following editorial clipped by one of our readers from a recent issue of the New York Daily News, breathes a sentiment upon which a volume could be written:

"There are many thousand citizens in this country who believe that we are burdened with too much law.

It is undoubtedly true that there are many laws on our statues, city, State and Federal, that are obsolete, ignored and should be repealed. It is just as certain that we lack laws for the preservation of life, property and the pursuit of happiness which only circumstances will finally put in force.

If there had been two engineers in the engine room of the ferryboat American, of the Williamsburg line, yesterday evening, the accident injuring many passengers and endangering the lives of all could not have been possible.

It is only quite recently that a law was passed making it compulsory that there be at all times two pilots in the pilot house of every steam passenger vessel.

This accident of last night, which fortunately did not result in a loss of life, is subject to repetition on any of our numerous ferry lines at any moment. Must we wait until a long death list caused by the sudden death of an engineer at his post results, or will our lawmakers take the matter up, now that they are so forcibly warned?"

The above affords material for careful thought. In many cases it applies to stationary work with special force. See how many places you can recall where the lives of many persons often depend upon the life and action of a lone engineer who day after day spends hours at a time in an engine room in the basement or several hundred feet away without being seen by anyone.

## The Use of Superheated Steam and of Reheaters in Compound Engines of Large Size.*

By Lionel S. Marks.

The object of this paper was to collect and present the results of a number of unpublished tests made during the past five years on several high-speed, two-cylinder compound engines, all built by the same makers, and all of the same type. The engines tested differ from one another only in size, in cylinder proportions, and in their working conditions. The investigations were made to determine the performance of the engines under different loads, both with and without jacketing and reheating. A comparison of the results for the different tests throws some light upon the influence on the thermal efficiency of large sized four-valve compound engines of the following factors:

*(a)* The use of a reheater.
*(b)* The use of moderately superheated admission steam.
*(c)* The load.
*(d)* The size of the engine.
*(e)* The cylinder proportions.

The results recorded here are for tests made on nine separate engines and for twenty-eight different tests. The engines are parts of three electric lighting plants situated in or near Boston. The engine referred to as *A*, is at the L Street station, South Boston, of the Edison Electric Illuminating Company—a plant which at the time of the test was the property of the Boston Electric Light Company. The tests at this station were conducted by the writer. Engines *B, C, D, E* and *F* are at the Atlantic Avenue station of the Edison Electric Illuminating Company, and they were tested under the joint supervision of an employee of the Company and a representative of the engine builders. Engines *G, H* and *K* are at the new plant of the Cambridge Electric Light Company, and were tested by the writer.

### DESCRIPTION OF THE ENGINES.

The engines tested vary from 750 to 2500 rated horse power, and were all built by McIntosh, Seymour & Company, of Auburn, N. Y. They are all vertical, high-speed, two-cylinder, cross-compound, direct-connected units with overhanging crank. Each cylinder is supported on a heavy, hollow, cast-iron frame at the back and on two inclined steel standards in front. Each high-pressure cylinder is jacketed on the barrel and both heads, and the jackets are piped in series; the steam enters the jacket on the top head, passes into the barrel jacket, goes to the jacket on the lower head and then to the reheater coils. In this way a very active circulation in the jackets is ensured. As there is no separate steam supply to the reheater coils, nor any separate drain from the high-pressure jackets, it was not possible to use either the jackets or the reheater alone. The receivers are of the large cylindrical drum-type, located at the back of the engine and close to the cylinders. The reheater consists of one or more coils of pipe in the receiver. The low-pressure cylinder is unjacketed.

The valves are of the flat, gridiron type, unbalanced and of short stroke. The steam valves on both high-pressure and low-pressure cylinders consist of a main valve cutting off at about .8-stroke, and a Rider cut-off valve, the movement of which can be varied so as to give any desired cut-off. The main steam valves and the exhaust valves on each cylinder are driven from an eccentric on the main shaft through a system of links and levers. The cut-off valves are driven by auxiliary eccentrics, which are controlled by a fly-wheel governor. The action of the valves is rapid; the openings for admission and exhaust of steam are large.

The fly-wheel governors are designed to control the speed within 2 per cent. variation between zero load and full load. At the Cambridge electric light station the position of the governor weights can be regulated when the engine is running by means of a small electric motor fastened to the fly-wheel and controlled from the switchboard. This device is valuable for synchronizing in parallel running.

### THE TESTS.

(The author here described the arrangements made for testing the engines, which was carried out with the greatest possible care with reference to preventing leakage from boilers, feed mains, steam pipes and connections; as all but one of the engines are fitted with jet condensers, their steam consumption could be determined only by measuring the boiler feed. The diameters of all cylinders were gaged when hot, the weighing scales for coal were carefully tested, and all gages, thermometers and indicators were carefully recalibrated. The results of the tests are summed up in an interesting form in the accompanying table.)

## RESULTS:

### THE VALUE OF HIGH-PRESSURE JACKETS AND OF REHEATING.

There are certain facts which the writer believes may be postulated with reference to the effectiveness of jacketing and reheating, and which are supported by the results of these tests. The saving by jacketing varies with the following factors:

*(a)* It increases as the cut-off becomes earlier.
*(b)* It decreases as the superheat of the entering steam increases.
*(c)* It decreases with increase in size of the engine.

There is no saving by reheating when the reheater does no more than to dry the steam. If there is any advantage in using dry and saturated steam in the low-pressure cylinder over the use of wet steam, it can be obtained by the use of a separator between the cylinders. In tests 2, 7, 9 and 24, when the reheater was not in use, the receiver acted as an almost perfect separator, taking away all the condensation which calculations showed to have occurred in the high-pressure cylinder. If the reheater merely vaporizes the condensed steam at the expense of a practically equal quantity of high-pressure steam it is not only non-effective but is also, probably, a source of actual loss, since more work could have been obtained from the total steam used if it had all gone into the high-pressure cylinder.

The reheater then should be regarded merely as a superheating device for the steam entering the low-pressure cylinder, and it may be expected to be more effective the greater the amount of superheat it gives the receiver steam. It is probable that the reheater would be more effective if the only work were superheating, as it might be if the wet steam exhausting from the high-pressure cylinder passed through a good separator before reaching the reheater. As the reheater will have less to do when the engine is running at low loads it may be expected to give a higher superheat at low loads, and, consequently, to be more effective. With the above in mind, an examination of the tests, the principal results of which are presented in the accompanying table, throws some light on the con-

*Abstract of paper presented at the Chicago meeting of the American Society of Mechanical Engineers, June 2, 1904.

ditions under which the jacketing of the high-pressure cylinder and the practice of reheating are desirable, and shows the saving to be expected from them in large size engines.

In engine *A*, when saturated steam is used, the jackets, at full load, keep the steam about 6 per cent. dryer in the high-pressure cylinder and the reheater superheats 35 degs. As the greater part of the 6.8 per cent. of the total steam which is condensed in the jackets and reheater must have been condensed in the latter place, it is obvious that the reheater cannot have contributed anything to the small saving of 1.3 per cent.

The conditions in engine *B* are much more satisfactory for effective action of jackets on reheater, especially at the lower loads. The engine is smaller, and its reheater more effective. At half-load, with 75 degs. superheat of the receiver steam, the saving was 9 per cent.; at three-fourths load, with 60 degs. superheat, there was 7 per cent. saving; at full load, with 46 degs. superheat, there was still 7 per cent. saving, and even at one-quarter overload, with 26 degs. superheat, there was 4 per cent. saving. The larger engines, *C* and *D*, with 80 degs. and steam from Babcock & Wilcox boilers, fitted with superheaters giving from 100 degs. to 125 degs. superheat at the boiler when running at the rated power. The amount of superheat at the engine depends on the load at which the engine is running; *(a)* because the superheat at the boiler decreases as its load is decreased, and *(b)* because the fall of temperature in the steam pipe increases as the weight of steam passing through it diminishes. For these two reasons the superheat was less at low loads than at higher loads, except in some cases where the number of boilers used could be decreased as the load decreased. As the superheat going to the low-pressure cylinder when the reheaters were in use varied in the opposite way, that is, increased with decrease of load, these two variations tended to offset one another in their influence on the engine efficiency. The tests without the reheaters in use will then be the most valuable for showing the influence of the superheat of the high-pressure steam. The tests at full load show that engine *A* uses 248 B. T. U. per indicated horse power per minute with no superheat; engine *C*, of about the same size, with 78 degs. superheat, uses 239 B. T. U., and engine *D*, with

TABLE OF PRINCIPAL RESULTS OF ALL THE TESTS

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Number of test | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | |
| 2 | Engine | A | A | B | B | B | B | B | B | B | B | B | B | C | C | C | C | D | D | E | E | F | G | G | H | K | K | K | K | |
| 3 | Nominal load | 1 | 1 | ¾ | ½ | ¼ | ¾ | ½ | 1 | 1 | 1¼ | 1 | 1 | 1 | 1 | ¾ | ½ | 1 | ¾ | 1 | ¾ | 1 | 1 | 1 | 1½ | 1 | ½ | ½ | ½ | |
| 4 | Duration of test, hours | 10 | 5 | 2 | 2 | 2 | 2 | 2 | 5 | 2 | 1 | 8 | 8 | 10 | 5 | 4 | 4 | 8 | 8 | 8 | 8 | 8 | 10 | 10 | 9 | 10 | 8 | 8 | 8 | |
| 5 | With or without jackets and reheaters | With | Without | With | With | Without | With | Without | With | Without | With | Without | With | With | Without | With | With | With | With | With | With | With | With | Without | Without | With | With | With | Without |
| 6 | Nominal H. P. cylinder diameter, inches | 98 | 98 | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 18 | 31 | 31 | 31 | 31 | 31 |
| 7 | Nominal L. P. cylinder diameter, inches | 58 | 58 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 36 | 64 | 64 | 64 | 64 | 64 |
| 8 | Stroke, inches | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 56 | 56 | 56 | 56 | 56 | 56 | 56 | 56 | 56 | 48 | 48 | 42 | 48 | 48 | 48 | 48 | 48 |
| 9 | Revolutions per minute | 118.46 | 118.46 | 103.6 | 103.4 | 103.1 | 102.5 | 102.5 | 101.9 | 101.9 | 101.2 | 101.2 | 101.9 | 97.48 | 97.64 | 96.77 | 99.6 | 98.2 | 98.6 | 99.7 | 100.7 | 98.53 | 118.4 | 119.1 | 119.15 | 116.9 | 119.1 | 119.3 | 116.37 | |
| 10 | Steam pressure at throttle, pounds per square inch | 159 | 161 | 152.6 | 151.5 | 155.3 | 150 | 155.1 | 160.5 | 155.9 | 158.6 | 155.2 | 161.8 | 168.6 | 167 | 167 | 169.4 | 162.8 | 168.1 | 159.2 | 160.4 | 158.7 | 186 | 137 | 181 | 136 | 132 | 136 | 135 | |
| 11 | Superheat at throttle, degrees, Fahr | Wet | Wet | 8 | 4.6 | 21.8 | 10.7 | 17.5 | 9.2 | 14.6 | 8 | 13.6 | 16.6 | 80.2 | 78.5 | 54.5 | 48.3 | 98.4 | 98.4 | 72.4 | 70.4 | 92.7 | 78.2 | 75 | 55.5 | 64.2 | 70.8 | 35.3 | 73.5 | |
| 12 | Initial steam pressure in H. P. cyl., by cards | 156 | 158 | 97.8 | 180 | 153.6 | 131.6 | 138.7 | 130 | 134.8 | 131.2 | 135.9 | 140 | 158 | 155.5 | 155.4 | 160.5 | 157 | 157.3 | 156 | 153.3 | 150 | 169.9 | 126.9 | 130 | 132.9 | 122.4 | 95 | 126.1 | |
| 13 | Steam pressure in receiver, gage | 81 | 80 | 1.33 | 6.8 | 7. | 13.8 | 11. | 16.5 | 13.8 | ---- | 19.7 | 20. | 18.7 | 11.1 | 10.1 | 5.5 | 13.5 | 12.3 | 14 | 7.5 | 14.5 | 8.9 | 11.1 | 13.1 | 10.6 | 5.1 | 1.5 | 3.6 | |
| 14 | Superheat entering L. P. cylinder, degrees, Fahr | 35.5 | Wet | 92.8 | 75.4 | Wet | 60.5 | Wet | 46.6 | Wet | 26.5 | Wet | 49.4 | 60.3 | Wet | 67 | 84.8 | 60.5 | Wet | 60.9 | 86.0 | 61.7 | Wet | 49.1 | Wet | 40.3 | 59 | 79.1 | Wet | |
| 15 | Effective vacuum in L. P. cylinder, ins., by cards | 24.05 | 23.05 | 26.7 | 26. | 25.9 | 26.5 | 25.8 | 25.8 | 25.9 | 24.6 | 25.6 | 25.5 | 26.3 | 26 | 25.9 | 24.3 | 24.3 | 24.4 | 24.8 | 24.4 | 24.8 | 11.8 | 12.8 | 11.8 | 11.9 | 12.1 | 12.5 | 12.22 | |
| 16 | Vacuum in exhaust pipe, inches | 25 | 24.5 | 26.8 | 26.6 | 27.25 | 26.3 | 27.1 | 27.7 | 28.0 | 25.2 | 26.6 | 27.0 | 24.9 | 24.7 | 25.6 | 26.1 | 25.6 | 25.7 | 25.3 | 25.4 | 26.1 | 25.2 | 26.3 | 26.1 | 25.4 | 25.4 | 26.4 | 25.8 | |
| 17 | I. H. P., total | 1,994 | 1,984 | 909 | 562 | 568 | 845 | 831 | 1,047 | 1,105 | 1,498 | 1,516 | 1,104 | 2,267 | 2,240 | 1,831 | 1,239 | 2,202 | 2,215 | 2,230 | 1,259 | 2,171 | 715 | 716 | 858 | 2,184 | 1,196 | 716 | 1,198 | |
| 18 | I. H. P., H. P. cylinders | 959 | 962 | 121 | 308 | 247 | 316 | 368 | 113 | 507 | 606 | 702 | 415 | 1,098 | 1,218 | 874 | 573 | 1,093 | 1,189 | 1,119 | 633 | 1,008 | 384 | 347 | 464 | 1,084 | 605 | 331 | 647 | |
| 19 | I. H. P., L. P. cylinders | 1,105 | 1,022 | 788 | 349 | 301 | 529 | 463 | 934 | 598 | 892 | 814 | 689 | 1,169 | 1,022 | 957 | 666 | 1,109 | 1,026 | 1,111 | 626 | 1,163 | 331 | 369 | 394 | 1,120 | 591 | 385 | 551 | |
| 20 | Percentage of power developed in H. P. cylinder | 43 | 48.5 | 39.4 | 38.8 | 45.1 | 37.4 | 44.7 | 39.5 | 45.9 | 40.6 | 46.3 | 37.5 | 48.5 | 54.3 | 47.8 | 46.2 | 49.1 | 53.8 | 50.2 | 50.3 | 46.5 | 53.7 | 48.6 | 54 | 48.8 | 51 | 46.2 | 54.5 | |
| 21 | Total steam per I. H. P. per hour, lbs | 13.59 | 13.68 | 14.04 | 13.71 | 15.11 | 13.63 | 13.72 | 13.59 | 14.41 | 14.57 | 15.16 | 13.56 | 12.73 | 12.96 | 12.71 | 12.38 | 11.57 | 11.69 | 11.67 | 11.78 | 11.67 | 14.13 | 13.21 | 13.13 | 12.50 | 12.32 | 12.95 | 12.90 | |
| 22 | Per cent of total steam used in jackets and reheater | 6.8 | ---- | 10.9 | 6.95 | ---- | 7.91 | ---- | 7.49 | ---- | 8.9 | ---- | 6.9 | 6.5 | ---- | 7.2 | 9.3 | 7.4 | ---- | 7.1 | 9.3 | 5.6 | ---- | 6.45 | ---- | 4.89 | 7.28 | 9.05 | ---- | |
| 23 | Wet steam in jackets and reheater per I. H. P. hour, lbs | .92 | 0 | 1.43 | 1.23 | ---- | 1.06 | ---- | .95 | ---- | .91 | ---- | .94 | .83 | ---- | 91 | 1.15 | .86 | ---- | .83 | 1.09 | .66 | ---- | .85 | ---- | .61 | .89 | 1.17 | ---- | |
| 24 | Per cent of cylinder steam drained from receiver | 1.6 | 6.0 | ---- | ---- | 3.7 | ---- | 6.7 | ---- | 5.97 | ---- | 4.97 | ---- | ---- | 2.8 | ---- | ---- | ---- | ---- | ---- | ---- | ---- | 3.35 | .69 | 6.12 | .93 | .67 | ---- | 3.75 | |
| 25 | Quality of steam at cut-off H. P. cylinder | 81.6 | 75.5 | 85 | 80 | 86 | 78 | 88 | 80 | 74 | 68 | 74 | 68 | 86 | 86 | 77 | 85 | 90 | 93 | 94 | 82 | 89 | 78 | 85 | 88 | 93 | 88 | 81 | 90.5 | |
| 26 | Quality of steam at release H. P. cylinder | 85.6 | 79.6 | 85 | 85 | 88 | 80 | 74 | 78 | 75 | 93 | 78 | 81 | 83 | 88 | 82 | 80 | 94 | 87 | 94 | 92 | 84 | 75 | 85.5 | 83 | 93 | 88.5 | 88 | 92 | |
| 27 | Quality of steam at cut-off L. P. cylinder | 92.4 | 87 | 95 | 90 | 85 | 89 | 78 | 90 | 76 | 94 | 88 | 90 | 99 | 84 | 93 | 99 | 100 | 96 | 93 | 85 | 100 | 84 | 89 | 84 | 96 | 93 | 97.4 | 90.5 | |
| 28 | Quality of steam at release L. P. cylinder | 95.5 | 93 | 95 | 95 | 91 | 88 | 90 | 91 | 83 | 96 | 89 | 93 | 96 | 91 | 95.5 | 90 | 96 | 94 | 98 | 94 | 100 | 87 | 93.3 | 92 | 97 | 96 | 100 | 94 | |
| 29 | H. T. U. per I. H. P. per minute | 945 | 948 | 948 | 959 | 977 | 951 | 970 | 968 | 957 | 955 | 961 | 956 | 944 | 935 | 927 | 917 | 921 | 931 | 931 | 921 | 931 | 954.9 | 945.3 | 963.3 | 927.3 | 939.6 | 941.5 | 944 | |
| 30 | Thermodynamic efficiency, per cent | 17.3 | 17.1 | 16.5 | 16.9 | 15.4 | 17.0 | 15.8 | 17.2 | 15.9 | 16.7 | 16.1 | 17.6 | 18.0 | 17.4 | 18.1 | 18.7 | 19.6 | 18.7 | 19.6 | 19.6 | 19.2 | 16.0 | 17.3 | 17.4 | 18.7 | 18.7 | 17.6 | 17.4 | |
| 31 | Thermodynamic efficiency compared with ideal cycle | 68.4 | 66 | 58 | 60 | 60.5 | 59 | 62.5 | 58 | 66.1 | 61.5 | 64.5 | 68.3 | 65.6 | 67.3 | 67.7 | 73.4 | 73.3 | 72.6 | 73 | 70.7 | 68.8 | 67.4 | 68.5 | 74.2 | 73.3 | 68.8 | 67.5 | | |
| 32 | Per cent saving by jacketing and reheating | 1.3 | ---- | ---- | 0.0 | ---- | 8.0 | ---- | 7.0 | ---- | 4.0 | ---- | 3.0 | ---- | ---- | ---- | 4.5 | ---- | ---- | ---- | ---- | ---- | ---- | 7.5 | ---- | ---- | 7.2 | ---- | ---- | |
| 33 | Engine friction at no load, I. H. P | 118 | ---- | ---- | ---- | ---- | ---- | ---- | 70.5 | ---- | ---- | ---- | ---- | 159 | ---- | ---- | ---- | 169 | ---- | 164 | ---- | 197 | ---- | 50 | 50 | ---- | ---- | ---- | ---- | |
| 34 | Mechanical efficiency at rated load, per cent | 94.1 | ---- | ---- | ---- | ---- | ---- | ---- | 94 | ---- | ---- | ---- | ---- | 93.2 | ---- | ---- | ---- | 92.7 | ---- | 93 | ---- | 91.4 | ---- | 93.4 | 93.4 | ---- | ---- | ---- | ---- | |

98 degs. initial superheat and 60 degs. superheat by the reheater, show but 3 per cent. and 4.5 per cent. saving respectively.

The engine *G* is only one-third the power of engines *C* and *D*, consequently the jackets are much more effective (raising the steam quality 10 per cent. in the high-pressure cylinder), so that with 49 degs. superheat going to the low-pressure cylinder, the saving is 7.5 per cent. The tests on engine *K* at half-load, with 59 degs. superheat by the reheater, show 7.2 per cent. saving. The engines *C*, *D* and *K* have sufficient initial superheat and are of such size as to make the high-pressure jackets of but little value, so that the savings shown are due principally to the action of the reheater.

A study of the above results appears to indicate that the reheater will not justify its use (except as a separator) unless it superheats the low-pressure admission steam at least 30 degs. An examination of the qualities at release in the low-pressure cylinders indicates that 100 degs. superheat of the receiver steam will probably be enough to make the steam dry and saturated at release. As it is not desirable to have superheated steam at release, this suggests the probable desirable limit to the amount of superheat to be given by the reheater.

### THE VALUE OF MODERATE SUPERHEATING.

The engines *C*, *D*, *E*, *F*, *G*, *H* and *K* were all supplied with steam from Babcock & Wilcox boilers, fitted with superheaters giving from 100 degs. to 125 degs. superheat at the boiler when running at the rated power. The amount of superheat at the engine depends on the load at which the engine is running; *(a)* because the superheat at the boiler decreases as its load is decreased, and *(b)* because the fall of temperature in the steam pipe increases as the weight of steam passing through it diminishes. For these two reasons the superheat was less at low loads than at higher loads, except in some cases where the number of boilers used could be decreased as the load decreased. As the superheat going to the low-pressure cylinder when the reheaters were in use varied in the opposite way, that is, increased with decrease of load, these two variations tended to offset one another in their influence on the engine efficiency. The tests without the reheaters in use will then be the most valuable for showing the influence of the superheat of the high-pressure steam. The tests at full load show that engine *A* uses 248 B. T. U. per indicated horse power per minute with no superheat; engine *C*, of about the same size, with 78 degs. superheat, uses 239 B. T. U., and engine *D*, with 98 degs. superheat, uses 226 B. T. U., a saving of about 9 per cent.; some of which, however, is also due to a better vacuum and better cylinder proportions. Engine *B*, a smaller engine, uses 267 B. T. U. with 15 degs. superheat—which is practically the same result as that obtained from engine *G*, a still smaller engine, with a poorer vacuum but with 72 degs. superheat. In the test of engine *D*, with 98 degs. superheat, the quality of the steam at release is 87 per cent., so that it is evident that when the jackets are not used, a much greater superheat is desirable in order to prevent condensation in the high-pressure cylinder—probably at least 150 degs. will be necessary. An even greater superheat will be necessary to keep the steam dry in both cylinders. With the jackets in use and with 98 degs. superheat the quality in the high-pressure cylinder at cut-off is 99 per cent., and at release is 94 per cent. The advantage gained by superheating is, of course, greater in the smaller engines.

### THE VARIATION OF ECONOMY WITH ENGINE LOAD.

The engines *B*, *C*, *E* and *K* were all tested at several loads so as to determine the effect of variation of engine load on the efficiency of the engine. In all the cases (engines *C*, *E* and *K*) where moderately superheated steam was admitted to both cylinders, the important fact was brought out that the heat consumption per indicated horse power is practically constant

through a range of load varying from one-half load to a full load, and probably even to a considerable overload. The apparent exception in the better performance of engine *C* at half-load is probably due to a better vacuum at that load. The general result was to be expected, because the effect of superheat is to reduce the amount of heat disappearing during admission, and, consequently, to permit the increased expansion at low loads to occur without excessive cylinder condensation. In engine *B*, with very small superheat of the admission steam, there is a slight decrease in economy as the load decreases from full load, and in the tests without reheater, and, consequently, with no superheat going to the low-pressure cylinder, this decrease in economy is very marked.

It is, perhaps, hardly necessary to emphasize the fact that the constancy of heat consumption referred to above is in terms of the indicated horse power. In all these engines the friction horse power is low, and the mechanical efficiencies at the rated loads are high, varying (see table, line 34) from 91.4 per cent. to 94 per cent., and averaging 93.2 per cent. The friction horse powers were determined by taking cards with no load on the engine, but they really represent more than the friction of the engine proper, since they include some losses properly chargeable to the generator—such as the brush friction, the armature windage, the bearing friction of the armature and, in some cases, a low excitation of the field. Consequently, the real mechanical efficiencies of the engines are somewhat higher than the quantities given in the table.

The low friction of the engine causes the heat consumption per electrical horse power to change a comparatively small amount as the load decreases; the heat consumption per kilowatt per hour will be some 6 per cent, or 7 per cent. greater at half load than at full load.

### THE RADIATION AND CONDUCTION HEAT LOSSES.

In these tests where the reheater was in use, the knowledge of the exact condition of the steam entering the low-pressure cylinder permitted the determination of the heat lost by radiation and conduction from the high-pressure cylinder and the receiver. The total heat of the steam coming to the engine is the sum of the four following quantities:

(1) The heat going to the low-pressure cylinder.

(2) The heat equivalent of the work done in the high-pressure cylinder.

(3) The heat escaping with the reheater and receiver drainage.

(4) The heat lost by radiation and conduction from the high-pressure cylinder and the receiver.

The first three quantities can be calculated from the observations made on the test, and, consequently, the last quantity can be determined by the heat balance stated above. The radiation and conduction loss was calculated for most of the tests, and was found to vary from ½ per cent. to 1 per cent. of the total heat supply to the engine at full load. As the low-pressure cylinder is as carefully lagged as the high-pressure, it appears that from 1 per cent. to 1½ per cent. of the total heat supply to the engine at full load will be lost by external radiation and conduction. The larger percentage applies to the smaller engines.

### PISTON LEAKAGE.

The steam qualities at cut-off and release, given in lines 25 to 28 of the table, show considerable variation in different engines running under practically the same conditions. The reason for this variation is apparently not far to seek, and depends on a phenomenon to which but small consideration is generally given in the discussion of steam engine performances. This phenomenon is piston leakage.

Most of the engines were tested when at rest for piston leakage, before the runs were made, and in no case was there any but slight leakage. It is probable, however, that a piston which is quite tight when at rest will leak when running. The static leakage tests were made for a small number of piston positions, and did not insure static steam tightness in every position. There is evidence, moreover, to show that even if the piston is tight in every position when at rest, it may leak when in motion owing to the breaking up of the oil film on the cylinder walls. If to the results of the leakage test of the piston is added the knowledge that an intelligent engineer has of the condition of the cylinders of which he has had charge, it is probable that a more accurate statement can be made as to the tightness of the pistons. From such data the following statements may be made as to the condition of the engines tested:

Engine *B*, neither piston perfectly tight, but both in good condition.

Engine *C*, no appreciable leakage.

Engine *D*, both cylinders in very good condition.

Engine *E*, high-pressure cylinder very good; low-pressure piston had not worn down to maximum tightness.

Engine *F*, high-pressure cylinder had been scored a few weeks before test, and had not worn quite tight; low-pressure cylinder unusually good.

Engine *H*, high-pressure cylinder very good; both cylinders better than engine *G*.

The above conditions, as known before the tests, will be found to explain most of the variations in steam quality to which reference has been made. For example, of the two similar engines, *E* and *F*, the latter shows lower quality at cut-off in the high-pressure cylinder, notwithstanding a greater initial superheat—and this quality is seen to decrease throughout expansion. Leakage past the high-pressure piston readily accounts for this. In the low-pressure cylinders of these two engines the phenomenon is reversed, and the remarkably high quality of the steam in engine *F* is presumably due to the unusually good condition of the cylinder.

Similarly comparing tests 22 and 24 on the exactly similar engines, *G* and *H*, under practically similar conditions, a marked advantage is seen in the quality of the steam during expansion in the high-pressure cylinder during the latter test—a result to be expected from the known better conditions of that cylinder.

These examples could be multiplied were it desirable. The effect of the piston leakages, when moderate, on the engine economy is not very great, since steam leaking by the high-pressure piston will be available for doing work in the low-pressure cylinder.

### CONCLUSIONS.

In summing up the general results of the tests the following conclusions appear to the writer to be justified when applied to large size, high-speed, compound, four-valve engines of common proportions.

The jacketing of the high-pressure cylinder is of but little value when moderately superheated steam (100 degs. F.) is used.

Reheating is probably a source of loss unless it superheats the receiver steam at least 30 degs. F., and is not fully effective unless it superheats about 100 degs. F. In the latter case it may be expected to effect a saving of 6 per cent. to 8 per cent. of the total heat used per indicated horse power.

Jacketing the low-pressure cylinder is shown by the steam qualities during expansion in the low-pressure cylinder to be unnecessary and, therefore, undesirable when the reheating is effective. The effect of admitting moderately superheated steam to both the high-pressure and low-pressure cylinders is to keep the heat consumption per indicated horse power practically constant throughout a considerable range of loads—from half load to about one-quarter overload.

The variation within the ordinary limits of the ratio of stroke to diameter in large size engines of the same power when using moderately superheated steam does not have any marked effect upon the economy of the engine. The size of the engine is an important factor in determining its efficiency. The engine *G* has about 10 per cent. greater heat consumption per indicated horse power than *K*, which is three times larger.

### Some Engineering Facts About the Panama Canal.

The Panama Canal, on which the eyes of the world are now centered, will, if completed, be one of the greatest engineering feats ever accomplished. This great commercial waterway will cost the United States not less than $200,000,000, and it is expected that it will take ten years to finish it. The canal across the Isthmus of Panama will be forty-nine miles in length, and connect the Atlantic and Pacific Oceans. Work was begun on the canal in 1881, by a body of French capitalists, who expected to complete the work in twelve years at a cost of $240,000,000. An enormous amount of machinery was purchased, 15,000 laborers were imported, and with very incomplete information, they started the most stupendous engineering undertaking of the age. Yellow fever, floods, incompetence, fraud and dishonesty, coupled with the impossible nature of the project itself, soon brought about the inevitable disaster, and in 1889 a receiver was appointed, who found the enormous sum of $246,000,000 had been squandered.

In 1894 a new company was formed for the purpose of completing the canal. Instead of cutting the channel straight through so that the water would always be at tide level, as the first company had intended to do, they adopted a plan for a canal 29½ feet deep, with a summit level of 97 feet, a second level of 68 feet and a third level of 33 feet above the sea; dams being used to maintain these levels.

These plans were pronounced perfectly feasible, and the cost estimated at $102,000,000. This company has done considerable work on the canal, but their labors have scarcely made an impression upon the mountains and cuts, although they still have laborers at work so that its charter and rights will not be forfeited. They have finished about fifteen miles of the canal in sections, but most of the work will have to be done over. It is for this amount of work and the machinery along the line of the canal that the United States has offered $40,000,000. The new canal, as our Isthmian Canal Commission proposes to build it, consists of a thirty-five foot canal, with ninety foot summit level and three locks, and is estimated to cost $144,000,000. Besides the canal, the Panama Railroad will have to be built along the canal, the cost of this being estimated at $1,200,000. The canal will be built so that the largest ships can pass through it, and time estimated in making the trip is about twelve hours.

### Proposed Standard for Cast-Iron Collars for Shafts.

BY JERRY LEAHEY JR.

| Diam. of Shaft. | Diam. of Collar. | Width of Collar. | Diam. of Set-screw. | Length of Set-screw. | Counter Bore for Set-screw. |
|---|---|---|---|---|---|
| 1 | 2 1-2 | 1 1-4 | 1-2 | 1-2 | 1-4 x 13-16 |
| 1 1-16 | 2 9-16 | | | | |
| 1 1-8 | 2 5-8 | | | | |
| 1 3-16 | 2 11-16 | | | | |
| 1 1-4 | 2 3-4 | | | | |
| 1 5-16 | 2 13-16 | | | | |
| 1 3-8 | 2 7-8 | | | | |
| 1 7-16 | 2 15-16 | | | | |
| 1 1-2 | 3 | | | | |
| 1 9-16 | 3 1-16 | | | | |
| 1 5-8 | 3 1-8 | | | | |
| 1 11-16 | 3 3-16 | | | | |
| 1 3-4 | 3 1-4 | | | | |
| 1 13-16 | 3 5-16 | | | | |
| 1 7-8 | 3 3-8 | | | | |
| 1 15-16 | 3 7-16 | | | | |
| 2 | 3 1-2 | | | | |
| 2 1-16 | 3 13-16 | 1 9-16 | 5-8 | 5-8 | 9-32 x 1 |
| 2 1-8 | 3 7-8 | | | | |
| 2 3-16 | 3 15-16 | | | | |
| 2 5-16 | 4 | | | | |
| 2 3-8 | 4 1-16 | | | | |
| 2 1-4 | 4 1-8 | | | | |
| 2 7-16 | 4 3-16 | | | | |
| 2 1-2 | 4 1-4 | | | | |
| 2 9-16 | 4 5-16 | | | | |
| 2 5-8 | 4 3-8 | | | | |
| 2 11-16 | 4 7-16 | | | | |
| 2 3-4 | 4 1-2 | | | | |
| 2 13-16 | 4 9-16 | | | | |
| 2 7-8 | 4 5-8 | | | | |
| 2 15-16 | 4 11-16 | | | | |
| 3 | 4 3-4 | | | | |
| 3 1-16 | 5 1-16 | 1 7-8 | 3-4 | 3-4 | 9-32 x 1 3-16 |
| 3 1-8 | 5 1-8 | | | | |
| 3 3-16 | 5 3-16 | | | | |
| 3 1-4 | 5 1-4 | | | | |
| 3 5-16 | 5 5-16 | | | | |
| 3 3-8 | 5 3-8 | | | | |
| 3 7-16 | 5 7-16 | | | | |
| 3 1-2 | 5 1-2 | | | | |
| 3 9-16 | 5 9-16 | | | | |
| 3 5-8 | 5 5-8 | | | | |
| 3 11-16 | 5 11-16 | | | | |
| 3 3-4 | 5 3-4 | | | | |
| 3 13-16 | 5 13-16 | | | | |
| 3 7-8 | 5 7-8 | | | | |
| 3 15-16 | 5 15-16 | | | | |
| 4 | 6 | | | | |
| 4 3-16 | 6 3-16 | | | | |
| 4 1-4 | 6 1-4 | | | | |
| 4 7-16 | 6 7-16 | | | | |
| 4 1-2 | 6 1-2 | | | | |
| 4 3-4 | 6 3-4 | | | | |
| 4 15-16 | 6 15-16 | | | | |
| 5 | 7 | | | | |
| 6 | 8 1-4 | 2 3-16 | 7-8 | 7-8 | 9-32 x 1 3-8 |
| 7 | 9 1-4 | | | | |
| 8 | 10 1-4 | | | | |
| 9 | 11 1-4 | | | | |
| 10 | 12 1-4 | | | | |
| 11 | 13 1-4 | | | | |
| 12 | 14 1-4 | | | | |

The accompanying table was compiled by an engineer who recently had a large amount of work to do upon shafts and shaft collars in the machine shop. While the shafts are of standard diameters, it was found that the cast-iron collars fitting them followed no standard, so that much difficulty was experienced for this reason, in repair work. This proposed standard, if followed, would do away with much of this trouble. We would be very much pleased to hear from engineers and manufacturers as to the advisability of such a standard, and in which direction, if any, it can be improved upon.

# LETTERS FROM ENGINEERS

IN ORDER to make this department of THE PRACTICAL ENGINEER as interesting as possible, a moderate rate will be paid by us for all contributions published under this heading. However, we do not assume responsibility for the ideas or opinions expressed. None need hesitate to contribute because of inability to draw or write well. We will redraw or revise whenever necessary—it is the idea we want. New ways of doing old things, criticisms of accepted theories, and general engine-room experiences are especially solicited.

## Opening and Closing Valves.

EDITOR THE PRACTICAL ENGINEER:

The letter of "A. T." in the June issue of your paper calls for a passing notice, as he condemns without qualification a practice that many engineers, including the writer, have adopted, resulting in convenience to ourselves without detriment to our employers.

I do not always have a mirror at hand when closing valves, so it is not possible to say definitely whether my face flushes at such times or not, but it is quite possible that it does. It may indicate ignorance of the proper way to handle valves, but if this is true it is because I did not use a wrench when the leverage provided by it would have made extra exertion unnecessary, hence my face would have retained its normal condition.

By way of explanation, would say that I have an 8-inch gate valve that controls one steam line. Personally, I am far from being an invalid, but after I seize the wheel of this valve and turn it down as far as possible, it leaks badly. What would "A. T." recommend in such a case? Would he allow steam to leak through this valve all night, wasting heat and water? If so, he is at liberty to adopt this course, but I prefer to put a wrench on the wheel and exerting moderate pressure on the handle, bring the valve down as tight as possible.

At present, some of my boilers are laid off on account of warm weather. Two of these are connected to the main steam pipe, common to all, by 6-inch Jenkins' angle valves. If these valves are shut by hand only, water leaks through them and corrodes the boilers, but by blowing steam through them, then judiciously using a wrench on their wheels, they are made tight. "A. T." may conclude that every man who puts a wrench on a valve wheel is an ignoramus; nevertheless, from my point of view, this fact does not constitute a good reason for discontinuing the practice, wasting steam and injuring idle boilers.

These valves were put into service ten years ago, and although the disks put in them when they were made lasted a long time, ordinary wear finally made it advisable to put in new ones, yet the seats are still in perfect order.

"A. T." says that this practice of using a wrench will ruin disks and spoil the best of seats in time. How long a time is required to do this? In my case, ten years is not sufficient to begin it, and judging from this condition, which is not a theory, how soon shall I be obliged to renew these valves, or have their seats replaced, which would be a rather expensive job? Let us have direct information on this point.

I have two pumps which receive water under pressure through 3-inch pipes. Occasionally it is necessary to clean and adjust the suction and discharge valves of these pumps. If the gate valves in the suction pipes are closed by hand only, they leak badly, but by exerting in a judicious manner, the leverage due to a 10-inch wrench on the wheels, they shut off the water completely. Now, which plan shows better judgment, to allow the room to be flooded while I work on the water ends of pumps, or to use a wrench as described, and keep the floor dry?

Theoretically, the way to consider this is as follows: If it requires a pressure of, say, 25 pounds per square inch of valve seat to make a valve tight when closed, does it hurt the valve more to secure this pressure by means of a wrench than if it was done by pulling directly on a wheel until we "flush up in the face?"

I have a 3½-inch throttle valve that can always be opened and closed by using only the little finger on my left hand, yet it is tight when closed. This fact is mentioned to show that I am fully aware that every valve does not require a wrench, although the former part of my letter shows that I believe in using a wrench wherever its adoption results in better work, also where it enables us to do the same work with less exertion.

These experiences of mine are given because they constitute a more positive argument than when the work of others along the same line is mentioned, but I know that many other careful engineers use a wrench in an intelligent manner on their valve wheels, therefore I do not care to let an unqualified condemnation of the practice go unchallenged.

New Haven, Conn. W. H. WAKEMAN.

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## Some Notes and Comments.

EDITOR THE PRACTICAL ENGINEER:

If anyone doubts the terrible energy of fire and water, the March issue of your Journal should thoroughly disillusionize him. The account of the Baltimore disaster is extremely interesting to those who could not be eye-witnesses of the devastation. The St. Louis water tube boiler explosion forms another strong argument in favor of better education in boiler-room forces, and illustrates what might have been prevented by proper licensing of engineers and firemen. It is to be regretted that the necessity of license laws must be impressed upon people by such a disaster as the one chronicled. After all, there can be no such thing as safety in an ordinary steam plant until a reasonable amount of intelligence is injected into the operating force. Any boiler can be wrecked by carelessness and ignorance on the part of attendants, and the engineering fraternity will award a well-earned medal to the man who shall contrive to design a boiler which, besides the usual desirable features, shall be also absolutely fool-proof.

In the article on page 6, the writer states that "if anything happens whereby the pump must be stopped for two minutes under ordinary circumstances, the plant must be shut down." Now, it seems hardly fair that an oversight on the part of the designing engineer should be charged up against the water tube boiler as a disadvantage. Where was the injector when the pump stopped? In all well-regulated plants, it is customary to provide at least two independent methods of boiler feeding. It seems rather poor policy to put all one's eggs into one basket, as would be done in relying wholly and solely

upon the feed pump to supply feed water, and if the man who laid out the plant forgot to specify anything except a pump, it appears that the blame should rest on him, and not on the boiler.

Regarding chimneys made of radial brick, spoken of on page 8 of the May issue, the author did not mention a point which came to my notice a few days ago. Near here there has just been erected a chimney of radial brick, 180 feet in height. At intervals of six feet there are wrought-iron bands extending around the outer circumference, their purpose being to further strengthen the structure, and also to prevent, as far as possible, the shearing off of the stack at an angle of 45° due to its own weight. For it is well-known that a cylinder under compression tends to sheer along a plane 45° from the vertical.

In the steam loop controversy, J. G. B. is quite right. It is possible to operate the loop without the use of a check valve next to the boiler, since the column of hot water and spray which is caught up in the riser is much lighter than an equal height of column in the drop leg. However, it is wise to put in a check valve, as F. H. S. would do; but not to improve the action. The reason for inserting the check valve is to prevent the boiler from being drained of water when the steam valve is closed, since then there is only one connection between the boiler and the separator, through the loop.

Scranton, Pa. X. N. Trick.

### A Universal Balancer.

EDITOR THE PRACTICAL ENGINEER:

The matter of balancing the running parts of machinery often gives rise to perplexing problems, especially if the parts are of the high-speed order. When the speed of a pulley is 1000 revolutions or more per minute, a slight discrepancy between its axis and centre of gravity will cause it to behave very badly; and the larger the diameter and the higher the speed, the more annoying and dangerous it becomes. Cutter-heads in wood-working machinery, which run as high as 6000, must be very nicely balanced or they will set up vibrations which will destroy all possibility of first-class work.

It is not the purpose of this short article to give methods of determining whether the running parts are in balance on the machine, but to give the method of balancing or trying for balance on the ways.

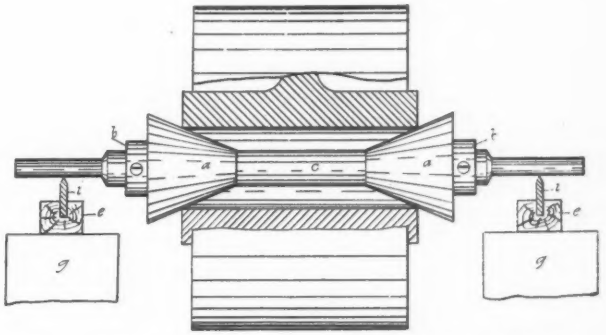
The accompanying illustration shows a very efficient and cheaply constructed balancer adapted for use with machine parts having bores in the centre.

The cones *aa*, are bored to a close sliding fit on the spindle *c*; the collars, *bb*, are turned up solid with the cones and serve to carry the set-screws; the spindle *c*, is turned down at each end to facilitate its rotation; the steel bars *ii*, are closely set in the wooden blocks *ee*, which rest upon a bench or any support represented by *g*. The drawing shows a pulley in place on the ways, with part of the rim broken away, and the hub longitudinally bisected in order to illustrate how the device will centre any bore from the largest to the smallest diameter of the cones.

When going about the task of balancing, level up the blocks from the top of the steel bars, being careful to have them parallel, and then centre the part to be balanced as shown in the cut. If it can be stopped at any point of rotation and remain at rest, it is in balance and the trouble it was supposed to cause should be traced elsewhere. If, however, it will stay at rest only with the same side down, it is out of balance and needs the centre of gravity driven to the axis.

If the discrepancy is slight and is to be overcome by drilling or filing, it is best to locate the light parts by sticking putty on the light side until the mechanism is in balance. It will be found in some cases that the putty will have to be distributed in several places in order to obtain a perfect balance. If the method of subtraction is used it will be necessary to take the metal away from exactly opposite the putty; but if the method of addition is employed, the counter-balance must be placed where the putty was, and in ordinary case, may equal it in weight.

Suppose the case of balancing a high-speed pulley 25 in. diameter, 1000 rev., having an oil-cup weighing ½ pound attached to the hub, with a counter-balance riveted to the rim. If the centre of gravity in the cup is 3 in. from the centre of motion, it naturally follows that the weight must be just ¼ that of the cup, as the centrifugal force varies directly as the distance from the centre of motion. This will work out all right on the balancer and any errors in weights or measurements will be corrected, while the difference between the cup filled and empty may be averaged by balancing it while half full.



Balancer adapted for use with Machine Parts having Bores in Centre.

The matter of speed does not enter into the calculations for the counter-balance, as centrifugal force is always the same for the same number of revolutions, and the only variance possible in a single unit of machinery is that of distance from the centre of motion, alluded to before.

The same ways may be used to balance parts already attached to their shafting or spindles. Care should be taken to have the upper edges of the steel bars slightly rounding so they will not cut into the spindle when balancing heavy parts.

St. Joseph, Mo. C. C.

### Massachusetts License Law.

EDITOR THE PRACTICAL ENGINEER:

I would like to say a few words in reference to the Massachusetts License Law, which you will find below, and which I send so that other engineers outside of Massachusetts can see what a reasonable law it is.

Some engineers say that the special license should be abolished. Now if they abolish the special license, how will the young man get experience? Let us suppose that there was a man holding a third-class license employed in a factory with engines of about 50 horse power, and suppose there was a

young man that wished to get experience. He could make application to the State examiner for a special license. Thus he could get experience from a licensed engineer, for he would work under him. He could work a short time there and then apply for a higher grade of license. If the special clause was abolished, he would stand no chance whatever. I believe that the law is well enough as it is and I say give the young man a chance and let the law alone, which is as follows:

"By the provisions of Section 78, Chapter 102 of the Revised Laws, it is unlawful for any person either to operate or to have charge of a steam boiler or engine (except boilers and engines upon locomotives and motor road vehicles, boilers in private residences, boilers in apartment houses of less than five flats, boilers under the jurisdiction of the United States, boilers used for agricultural purposes exclusively, and boilers of less than eight horse power), unless he holds a license.

Violation of this law is punishable by fine and imprisonment.

Licenses are divided into classes as follows: Engineers' licenses: First Class, unlimited. Second Class, to have charge of and operate any boiler or boilers and any engine not exceeding one hundred and fifty horse power. Third Class, to have charge of and operate a single boiler and any engine not exceeding fifty horse power. Firemen's licenses: First Class, to *operate* any boiler or boilers. Second, to have charge of and operate low pressure heating boilers where the pressure carried is less than twenty-five pounds per square inch. Hoisting and portable engines, and Special Licenses for any particular plant or type of plant. (NOTE.—Firemen desiring to *have charge* of a high pressure boiler must apply for a special license to have charge of such boiler, as a fireman's license does not permit holder to have *charge* of boilers.)

No person shall be entitled to receive more than one examination within ninety days.

The horse power of any boiler shall be ascertained upon a basis of three horse power for each square foot of grate surface for power boilers, and one and one-half horse power per square foot of grate for heating boilers.

Application must be made to examiner of city or town where applicant resides or is employed, upon appended application. Application must be accompanied by $1.00. Applicant will be notified when examination will take place.

A strict compliance with the law is expected and will be enforced.

No person can be examined for a Special License except a written request for such examination from owner or user of steam plant is filed with application."

Lunenburg, Mass. H. N. B.

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### Rodney's Troubles.
### Or Do We Need a License Law in Michigan?

(Ninth Letter.)

Mistur editur, deer sur, u havunt rit tu me fur a long tim and 2 fellars has bin hird at thu elecktrik lite stashun sinse i askd u about whut a fellar hed tu do whut is the seckund inginear in a power hous. ov corse, mr editur, i dont need the job in the power hous fur i kin du a lot ov wurk with mi thrasher injine, but i am a littel bit skiddish about the biler. a fu day's ago i wus kutten sum hay, and grindin sum feed for old man kelner, old hank, you node him. he hes livd in munrow kounty fur mor'n 35 yeers, whi he is the fellar whut sold the cirkus man the 5 leggad kow. well while i wus watchen the injine over thear, i hed jist put som kole in to the fire place and shut the door, when there wus a noize like az if sum 1 had struk the biler with a big hammur or a ax. i luked in the flreplace but ther wuz nothin rong, az i kud see. the onli thing i kud make out wus that mebby sum fellar whut wurks in the kole mine, and uses powdur fur to blo up the kole furgot and throde sum powdur in the kole whut I usd, and mebby sum fellar wants to git the thrashun to du whut ime duin, and he jist throde a chunk o sumthin in the kole to put me out ov bisnez.

when i lookd the biler ovur i seen 1 ov them things that is pounded ovur on the side ov the bilur, u no 1 ov them thear things with a littel hole in it whut holds the outside ov the boiler tu the inside. well the watur and steem wus runnin out ov thear. I tuk a 20 pennie nale and druv it in the hole and stopd the leek, but it is leeken in the fire place yit. i think as how the stuf, what evur it wuz, jist blode up and throde a peace ov kole agin the biler whur that thing was and the jar jist busted the thing and started it leeken. i druv a 20 pennie nale in the littel hole in the fire place and it stopd the leek so that thear iz no leeks now but u kin see whear the thing whut evur it wuz hit the biler, fur thear iz a kind of a swellin like, whut ude hev from the sting ov a bee, on ure face. this swellin is on both sides of the biler, now i want tu no whut i can git tu put in tu the biler tu take down that swellin, and if ther iz enny law fur to purtekt me from gitten blode up by a mistake. rite az sune as u kin fur i wood like tu heer frum u rite away.

rodney gumkirk
orkners korners, care of mi father.
munrow kounty
Mishegan

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### Queer Way to Get Draft to Cross-head Key.

EDITOR THE PRACTICAL ENGINEER:

A few days ago I was called into a local factory to repair a horizontal engine that had been in use about six months The guide bars were continually running hot and they could not be kept cool with a hose. They were so very slack that the cross-head had a full 1-16″ play, top and bottom. I carefully examined the cross-head for surface bearing and found that the shoes bore on the guide bars at the top of the crank-end and at the bottom at the piston end. The cross-head had the appearance of having had a sudden jar such as is shown after there has been water in the cylinder. I questioned the engineer but he said he never had any trouble with water in the cylinder. It was necessary to take out the piston from the cross-head, so, after taking the cotter pin from the cross-head key, I drifted out the key and to my surprise it came out very easy. I then placed the half of an old brass on the cross-head pin in such a way that I could put a wedge between it and the end of the piston rod which projected through the tapering hole of the cross-head about 3-16″. I was surprised, when the wedge began to draw, that a very light tap drifted the taper fit of the piston from the cross-head. I also noticed that something fell into the engine frame. I reached down and brought up two pieces of tin about 3½″ long by ¾″ wide. These pieces of tin had been put in the taper hole of the cross-head to prevent the piston from entering too far to allow for the draft of the key.

With the pieces of tin out, I tried the piston again and found it fitted all right but that the key was too narrow to draw the rod home, so I took a piece of 1-16" sheet iron and cut off a piece as wide as the key and nearly as long. This strip I put between the key and the draft side of the cross-head. With it in, I entered the key in the key way and drove it down good and tight. This strip gave ample draft to the key and there was no more trouble with the guide bars heating.

One thing in particular that I noticed in that engine room was the unusually fine equipment of tools that the engineer had; a complete set of machinists' tools, files and chisels of all kinds; in fact, most any and everything that is needed in the engine room. There was a lathe in another part of the building, where the engineer could make any repairs required. I asked the engineer where he got the fine kit of tools and he said that he had been working in the erecting department in a stationary engine shop before he got this job. I have since wondered if he was cleaning castings or wheeling out borings, after finding liners in the cross-head as he had. He won't line out that cross-head again that way, for he received his calls when the bill was handed to the general manager.

Masheenest.

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**The Engineers We've Had.**

No. 2.—The Cool-headed Engineer.

I never thought much of him, and I put him down to be
A feller that from danger or disaster soon would flee,
He seemed so easy-goin' and without a word to say,
Yet still I never ketched him sittin' down throughout the day.
We used to talk about him 'mong ourselves, when he'd go by
And joke about his patient look—we thought that we were fly;
But one day he did somethin' that showed us he was no fool,
And proved it pays to have an engineer who can keep cool.

'Twas over there, where Jennie runs that great big geared machine,
And every time I look at it I seem to see that scene
Which on that day nigh froze my blood, and all I did was stare
At them two great cogs dragging Jennie to them by the hair.
She used to have a habit then of letting down her locks,
When she'd be waiting orders, and she'd give us all the shocks;
Close to the cogs she'd sit and trim them, laughing at our fears,
And all our words of warning she would meet with daring jeers.
At last it came, she got too close, the teeth met, she was fast,
And slowly, inch by inch, she went, and we stood there aghast.
Some screamed, some yelled, some fainted. I stood there like a mule,
And everyone did everything but keep a little cool.

It happened in a second, tho' an age it did appear,
And where he came from, no one knows, but that there engineer
Made just two slashes with his knife, Jen's head dropped on his knee,
Her hair was gone, but she was saved, and then he called to me—
"Get some cold water, first," he said, "send some one else for grog,
She will not need a doctor, for she did not reach the cog.
'Twill be a lesson for her. Now she's better. There: don't cry!"
That engineer grew wonderful that minute in my eye.

Yes sir! I've found that though a man may be demure and quiet,
That is no reason he's a fool, or that his work he'll slight,
And I have found that blowhards, when a crisis comes are dead,
And by the quiet thinkers nearly always must be led.
And on more than one occasion since that accident, I've found
Whene'er a cool head's wanted, that there engineer's around.
It must be in their bisness, for they say that as a rule
In times of greatest danger—then the engineers are cool.

Detroit, Mich. J. J. H.

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**As Things Are Often Done.**

Editor The Practical Engineer:

The writer was employed as assistant engineer in a plant in one of the Middle States. This plant was shut down for boiler inspection. The boilers had been inspected and pronounced O. K. and everybody was hustling to get things in shape, putting on the handhole and manhole plates. Six of these boilers were horizontal return tubular and the others were plain cylinder boilers and were used only when we were hard pushed for steam to help out but were very little help, I will assure you. The chief noticed while we were about to put on the manhole plates of the tubular boilers that the boilers were about half full of water or about half of the tubes were covered and to my surprise he ordered the fires started. The fireman asked if they had the proper amount of water in them to start fires. I replied: "No." "Never you mind! You light your fires and do as I tell you. They will have, by the time the fires get any heat to speak of," the chief replied. I made a vigorous kick when I found he meant what he was saying and was told to mind my own business, as he knew what he was doing. In reply to him I said: "If that is the way you are going to do, I do not want anything to do with them." And he said: "You make me tired!" When the fires were started under those boilers there was no water in sight and so near as I could judge they did not show at the bottom try cock for 30 minutes sure.

The next day we had a fine job on our hands, the three top rows of tubes in four of the boilers had to be expanded, and on the top row of all of the four boilers the beading on the end of the tubes broke off quite a number of them. Some of the tubes had to be renewed and after that, while I was employed at that place, we were continually working on those tubes to stop leaks.

Whatever caused this man to do such a thing I could never tell, for he was a good engineer and knew better. But this incident was always a mystery to me. After awhile I became convinced that I had all the experience expanding tubes and calking leaks I wanted, so I got through. After that, about 12 years ago, I was employed in a large hosiery mill in one of the New England States, as general repair man in the machine shop. Steam fitting was included in my work. One day, the boss machinist ordered me to make repairs on front of the feedwater pipe on one of the boilers. It was the practice of this Company to have one boiler to lay up for a month at a time, they having five horizontal return tubular boilers, four of them in service all the time. The feed pipe arrangement was

of the Hartford Steam Boiler Inspection Company plan, which most all of the engineers are acquainted with. After I had finished my job on No. 3 boiler that I was making repairs on and which had been idle for about a month, the pipe was tested for leaks. The engineer ordered the fireman to cut the boiler in with the rest of the battery, and to my surprise, in less than three minutes that cold boiler that had been empty and laid up for over 3 weeks had 95 lbs. steam pressure. I could hardly believe it. I turned to the engineer and asked: "Is it possible you have connected that cold boiler and it empty with the rest of them?" "Sure," he replied; "what of it?" "Well," I replied, "if I was owner of this plant, you would see your finish as engineer of this plant. I would have a man who knew better."

Abington, Mass. A. T.

## QUESTIONS and ANSWERS

THE editor will be glad to receive from the readers of THE PRACTICAL ENGINEER, such questions relating to engineering subjects, as may, from time to time, occur to them. All questions and answers should be addressed to the editor and accompanied by the name and address of the writer, which will not be published, however, unless especially desired. It is the intention that questions shall be answered by the readers, and even though the editor may, from time to time, publish answers and questions, he especially desires the readers in such cases to contribute any further information, in connection with the points raised, that they may consider of interest. All questions and answers received by the editor will be published, as far as practicable, but he reserves the right of editing or rejecting any communication.

EDITOR THE PRACTICAL ENGINEER:

Will you please answer the following questions in your next issue?

(1). How do dealers estimate the horse power of an engine when it leaves the factory?

(2). If we had an engine estimated at a certain horse power by the dealers and we put a certain load on it and then doubled the load, would this reduce the estimated horse power, when we used the increased load, providing the steam pressure was constant?

Bakersfield, Cal. A. L. B.

(1). As the horse power of an engine depends upon a number of variables, such as initial steam pressure, point of cut-off, number of revolutions, etc., it is usual for engine builders to assume that the engine operates under a certain initial steam pressure, with a given cut-off, running at a certain number of revolutions with a given back pressure and lead. When these variable conditions are assumed, it is an easy matter to calculate the horse power which an engine will be capable of generating, if the diameter of the cylinder and length of stroke are known. It is the result of these calculations that gives the engine its rated or estimated horse power. Many engine builders rate their engines under a number of different conditions. For instance, take a 12" x 14" high-speed engine. It might run at 225, 250 or 275 revolutions per minute; it might cut off at ¼, ⅜ or ½ stroke and it might have an initial pressure of 80, 90, 100, 110 or 120 pounds per square inch or any intermediate combination between these figures, but in giving the rated horse power, since all these conditions are assumed, some even number such as the above is taken. The rated horse power for a 12" x 14" engine under the different conditions would then be as follows:

| Size of Cylinder | Rev. per min. | Horsepower of Engine cutting off Steam at | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | One-quarter Stroke | | | | | Three-eight Stroke | | | | | One-half Stroke | | | | |
| | | Initial Steam Pressure | | | | | Initial Steam Pressure | | | | | Initial Steam Pressure | | | | |
| | | 80 | 90 | 100 | 110 | 120 | 80 | 90 | 100 | 110 | 120 | 80 | 90 | 100 | 110 | 120 |
| 12 | | | | | | | | | | | | | | | | |
| x | 225 | 72 | 82 | 93 | 103 | 113 | 88 | 100 | 112 | 124 | 136 | 98 | 112 | 126 | 139 | 153 |
| 14 | 250 | 80 | 91 | 103 | 114 | 126 | 97 | 111 | 124 | 138 | 151 | 110 | 125 | 140 | 155 | 170 |
| | 275 | 89 | 101 | 114 | 126 | 138 | 106 | 121 | 136 | 151 | 166 | 120 | 137 | 154 | 170 | 187 |

From the above table, under the conditions specified, it will be seen that the rated horse power will vary from 72 to 187.

(2). When the load on the engine is doubled, since the steam pressure remains constant, the cut-off must increase sufficiently so that the internal work will balance the external work. This does not alter the estimated horse power under a given condition but increases the actual horse power under the new conditions. For instance, a rough rating often given an engine assumes only one set of conditions; that is, steam at 100 pounds initial pressure, cut-off ¼ stroke and a certain speed. If an engine does more or less work, it cannot affect this rating.—[Ed.]

EDITOR THE PRACTICAL ENGINEER:

Kindly solve the following problems for me:

(1). If your vacuum gauge stands at 26 inches, what is the absolute pressure on the condenser?

(2). If a boiler is 30 inches in diameter and 10 feet long, what is the pressure tending to tear it apart, if the steam pressure within it is 100 pounds per square inch?

(3). Disregarding friction, how many horse power will it take to elevate 10,000 gallons of water 90 feet in one minute?

Chicago, Ill. M. R. S.

(1). The pressure of the atmosphere under normal conditions is 14.7 pounds per square inch. This pressure is capable of balancing a column of mercury 30 inches high. For this reason, when a vacuum of 30 inches is spoken of it means that there is a negative pressure of 14.7 pounds below the pressure of the atmosphere or an absolute pressure of zero. For general calculation, one pound pressure is equivalent to 2 inches of mercury. Therefore, in the above problem, 26 inches of mercury corresponds to 13 pounds pressure, which is an equivalent to about 2 pounds absolute pressure.

(2). As the boiler is cylindrical, the internal pressure tends to tear it apart in two ways: longitudinally and transversely. The pressure per square inch is given as 100 pounds, so that it depends upon the nature and extent of the surface as to what the total pressure will be. The total pressure on the ends tending to burst it transversely is equal to the area of the head in square inches multiplied by the pressure per square inch. The total pressure tending to burst a boiler longitudinally is equal to the pressure per square inch multiplied by the diameter in inches multiplied by the length. In the above, therefore, assuming the whole area of the ends to receive the steam pressure, the total pressure to tear apart transversely $= .7854 \times 900 \times 100 = 76{,}086$ pounds and the total pressure

tending to tear it apart longitudinally equals $100 \times 30 \times 120 = 360{,}000$ pounds.

(3). A gallon of water weighs 8.33 pounds, so that 10,000 gallons weighs 83,300 pounds. As this water must be raised 90 feet in one minute, $83{,}300 \times 90 = 7{,}497{,}000$ foot pounds is the amount of work required. A horse power is the equivalent of 33,000 foot pounds in one minute, so that $7{,}497{,}000 \div 33{,}000 = 227$ horse power, the amount required to raise 10,000 gallons 90 feet high in one minute.—[Ed.]

EDITOR THE PRACTICAL ENGINEER:

Will you please answer the following questions and also give me the details of the calculations?

1. What horse power is exerted in pumping water to a battery of boilers for 18 hours which is furnishing steam to a 30" x 60" engine making 80 revolutions per minute, 130 pounds boiler pressure, using 25 lbs. of water per H. P. per hour, mean effective pressure = 60 pounds?

2. What is the H. P. of an engine under a prony brake test, if the weight on the scale is 150 lbs.; length of lever 63 inches from the centre of the shaft to the point on the scale; speed of engine, 200 revolutions per minute?

San Francisco, Cal. J. A. C.

1. In reference to the first question, it may be stated that the number of hours a boiler or an engine does a certain amount of work has nothing to do with the amount of horse power given out by it, because the term "horse power" takes in the time element, which is the amount of work done in one minute. An engine may do the same amount of work for hours and yet not generate or give out any more horse power. Therefore, in the above question, the number of hours that the boilers feed the engine has nothing to do with the problem.

As the engine uses 25 pounds of water per horse power per hour, it is first necessary to find the horse power of the engine. This is done by using the well-known formula:

$$\text{H. P.} = \frac{\text{PLAN}}{33000}$$

in which P = mean effective pressure in pounds per square inch, L = length of stroke in feet, A = effective area of the piston in square inches and N = the number of strokes per minute. Substituting the equivalent values, the formula becomes:

$$\text{H. P.} = \frac{60 \times 5 \times 706.86 \times 160}{33000} = 1028$$

which gives the horse power of the engine as 1028. As it requires 25 pounds of water to generate one horse power in one hour, the total weight of water required by the engine is $1028 \times 25 = 25{,}700$ pounds per hour. This water must be furnished by the boilers and pumped into the boilers by the pump.

The theoretical horse power of a pump is given by the formula:

$$\text{H. P.} = \frac{\text{Weight of water per min.} \times \text{height of lift-feet}}{33000.}$$

The weight of water required per minute is equal to $25{,}700 \div 60 = 428$ lbs. per minute. The height in feet is equivalent to the difference in pressure between the feed water pressure and the pressure in the boiler. Assuming the feed water pressure to be zero, the height of lift is equivalent to 130 pounds per square inch. One pound per square inch is equivalent to 2.3 feet head; so that if the difference in pressure is 130 pounds per square inch, this is equivalent to 299 feet head. Substituting in the above formula, we have

$$\text{H. P.} = \frac{428 \times 299}{33000} = 3.9$$

Owing to the slip in the pump and the friction of the water through it, the efficiency of a pump will not be much over 50 per cent., so that the horse power the pump would have to exert would be about 7.8 horse power.

2. The horse power of an engine under a prony brake test is obtained from the formula:

$$\text{H. P.} = \frac{6.2832 \times \text{L} \times \text{N} \times \text{P}}{33000}$$

in which L = length of lever arm in feet, N = number of revolutions per minute and P = downward pressure on the scales due to the rotating movement of the fly wheel. Substituting in the formula

$$\text{H. P.} = \frac{6.2832 \times 5.25 \times 200 \times 150}{33000}$$

which when worked out gives H. P. = 29.98, the brake horse power of the engine under test.—[Ed.]

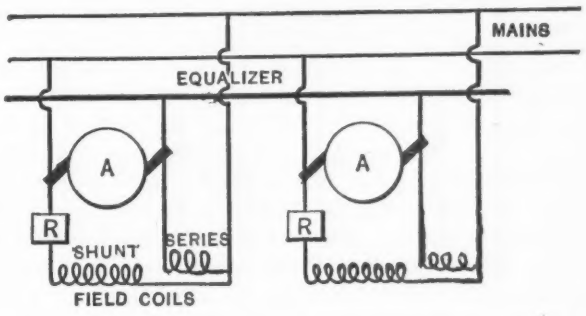
EDITOR THE PRACTICAL ENGINEER:

As a reader of your Journal, will you please explain to me the use and connections of the series and equalizer as applied in street railway machines?

Williamsport, Pa. T. O. J.

This can probably best be answered by first discussing the running of the shunt and series machines in parallel. The compound dynamo, which is used in street railway service, is a combination of the two principles. When shunt machines are connected in parallel it is expected that they will all be kept at the same pressure. If they are not, no serious damage is likely to occur, since the lower pressure machine merely falls to take its full share of the load. If the pressure of one machine falls so low that it is overpowered and runs as a motor, still no damage will result, save the blowing out of a fuse; since the direction of rotation for a shunt machine is the same whether it be running as a dynamo or as a motor.

If it be attempted to operate series dynamos in parallel, the following difficulties occur: If the machines start with a proper




distribution of load among them and one of them does not generate its full pressure, then this one does not continue to take its full share of the load, and since it is series wound a decrease in load is followed by a decrease in voltage. Since the direction of rotation of a series wound motor is opposite to its direction when running as a dynamo serious results may occur.

The only remedy for this trouble is to arrange the field coils so that the magnetization in any one machine will remain the same as in the other machines, even though its pressure falls below that of the others. To accomplish this the series field must all be placed in parallel. This may be done by means of an equalizer, which is a wire of small resistance connected across one set of brushes.

The use of compound generators make use of this principle, since they have series coils and cannot be run in parallel without this equalizer. The accompanying sketch shows the way they are connected.—[Ed.]

EDITOR THE PRACTICAL ENGINEER:

Will you kindly answer the following questions and give the rule for same?

1. I have a wood tank which holds 1295 gallons of water. There is an 1½"-pipe going into the same. How long will it take steam at 80 pounds pressure to raise the temperature of the water from 60° to 212° Fahr., the surface of the water being exposed to the atmosphere?

2. How many heat units will it take to raise the temperature of one gallon of water from 60° to 212° Fahr.?

3. How many heat units are contained in one pound of coal?

Roxborough, Pa. V. D.

1. The temperature of steam at 80 pounds gauge pressure is 324 degrees and as the temperature of the water in the tank must be raised from 60 to 212 degrees, the mean temperature of the water is 136 degrees, and the difference in temperature is 152 degrees. As a gallon of water weighs 8.35 pounds, the 1295 gallons weigh 10,813 pounds. This water must be raised 152 degrees in temperature, so that $1295 \times 152 = 196{,}840$ heat units required.

The number of heat units given up by one pound of steam when condensed from 324 to a mean temperature of 136 degrees is 1173 heat units. By dividing 196,480, the number of heat units required, by 1173, the result, which is 167.5 pounds, is the number of pounds of steam required. There are 4.57 cubic feet of steam in one pound, at a gauge pressure of 80 pounds, so that $167.5 \times 4.57 = 765.5$ cubic feet, which volume would be about 4000 cubic feet at atmospheric pressure.

Since this steam must flow through a 1½"-pipe, if the velocity with which the steam would flow was known, the time it would take to heat the tank would be known, exclusive of the amount lost by radiation. This velocity depends upon so many variables, such as the length and character of the pipe, the condition of the outlet and the amount of back pressure on the opening of the pipe,that it cannot be found accurately except by direct trial, as in this case the opening of the pipe is under the level of the water. The amount of evaporation would also be a factor as well as the amount of radiation, so that even if the velocity was known, the calculated results would differ widely from the actual time.

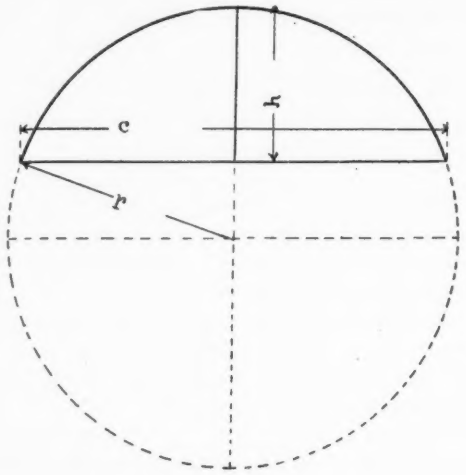
2. As one gallon of water weighs 8.35 pounds and as one heat unit is required to raise one pound of water one degree, the number of heat units required to raise one gallon of water from 60° to 212° will be $8.35 \times 152 = 1269.2$ heat units.

3. The number of heat units in one pound of coal depends upon the kind of coal and its composition, varying all the way from 10,000 to 14,000 heat units.—[Ed.]

EDITOR THE PRACTICAL ENGINEER:

Please tell me in your next issue how to find the diameter or radius of a circle having the height and base of the segment given as shown in the figure? The height of segment is 18" and the base of segment is 50".

Kansas City, Mo. D. T. D.




The relation between the height of the segment, the radius of the circle and the length of its base is as follows: Let H = height of segment, R = radius of the circle and C = length of chord or base of segment, then,

$$R = \frac{C^2 + 4H^2}{8H}$$

in which in the given figure, C = 50 and H = 18. Solving for R,

$$R = \frac{(50)^2 + 4(18)^2}{8 \times 18} = \frac{2500 + 1296}{144}$$

$$R = 26.36$$

which gives the radius of the circle as 26.36 inches.—[Ed.]

EDITOR THE PRACTICAL ENGINEER:

I am in charge of a 9½" x 12" slide valve engine. This engine is in perfect line. All bearings are as tight as will run cool and it has the proper lead. When running at 150 revolutions per minute, it strikes very heavy at both centres but when it runs at 100 revolutions with the same load it runs fair. I have known this engine about 7 years and it has run this way all the time and is no better, no worse. Will you kindly solve this for me?

Grant, Mich. A. C. B.

It is almost impossible to tell sometimes what is the cause of an engine knocking. Engines are very much like people, inasmuch as they often act very peculiarly. There is probably no engineer who has not had some trouble at some time with his engine knocking, and it is for this reason that an engineer prides himself when he has a smooth-running engine, as it is an indication of his ability as an engineer, although very often, in poorly-designed engines, it is not his fault.

It is probable in the above engine that there is some lost motion which is not very noticeable when the engine runs at the lower speed but is considerably aggravated when running

at the higher speed. This is not an unusual case, the reverse of which is also often true.

The most frequent causes of knocking in steam engines are lost motion in the cross-head, wrist and crank pin boxes; looseness in the main bearing boxes; looseness of the piston rod or follower plate; the crank pin or shaft being out of line with the cylinder; the wrist pin, crank pin or main bearing journal being worn oval; the slide-valve having too much or not enough lead; the exhaust opening being too soon or too late; shoulders being worn in each end of the cylinder, in consequence of the packing-rings not travelling over the counterbore at each end of the stroke; shoulders being worn on the guides, resulting from the cross-head shoes not overlapping them when the crank is at the dead centre; the piston not having sufficient clearance at either end of the cylinder, in consequence of its being altered by taking up the lost motion of the boxes; there not being sufficient draught in the keys to take up the lost motion in the connecting rod boxes; excessive cushioning, resulting from the leaky condition of the piston, which allows the steam to occupy the space between the cylinder and piston head. These are a few of the causes of knocking in steam engines.

The knocks arising from lost motion in any of the revolving, reciprocating or vibrating parts may usually be located by placing the finger on the part while the engine is being moved back and forth. Knocks induced by valve opening or closing too soon or by valves being improperly set can usually be found by using an indicator. Whatever the cause of the knocking may be, it is impossible to give a remedy for all engines, as, in many instances, it must be determined by the circumstances of each individual case.—[Ed.]

———o———

EDITOR THE PRACTICAL ENGINEER:

1. At how high a speed is it safe to run an engine 23″ x 44″ which has a fly wheel whose diameter is 12 feet?

2. Also what is the horse power of the engine when the steam pressure is 100 pounds per square inch?

Drew, Maine. E. I. L.

1. The maximum speed at which an engine can run depends in a large measure upon the speed for which it was designed to run. If run higher than its normal speed, there is danger of excessive wear of the moving parts; overheating of the crank pin and journals is likely to result; tendency to knock on centres is a serious objection, as well as excessive vibration of the engine parts. If the engine withstands these things successfully, the maximum speed is limited by the bursting speed of the fly wheel. Assuming a maximum allowable speed of 6000 feet per minute for the circumference of the fly wheel, the safe speed of the engine would be limited to 150 revolutions per minute.

2. An engine of the size mentioned, with 100 pounds initial pressure and one-quarter cut off, running at 75 revolutions per minute, would be capable of giving out about 425 H. P.—[Ed.]

———o———

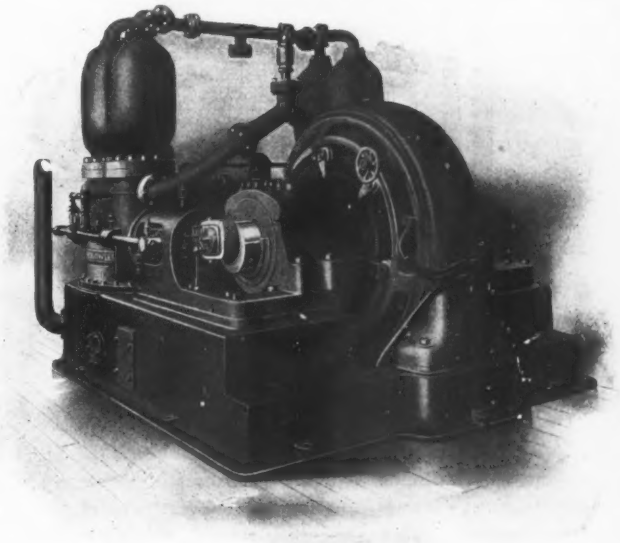
**A Motor-Driven Pump without Gears.**

At the St. Louis Exposition there is shown a high-speed electrically driven pump which makes use of the crank and connecting rod principle without the usual intervening gears. The shaft of the motor extends beyond the bearings on each side, on each end of which are cranks which are connected directly to the pump plungers. The pump is of the duplex type, the cranks at the opposite ends of the motor shaft being set at right angles to each other. The plungers are of the outside packed pattern and two plungers of each pump are connected by side rods.

Usually, electric-driven pumps are more or less objectionable on account of the toothed gearing, belts or other devices necessary to transfer the power from the rapidly revolving motor shaft to the slow moving crank-shaft of the pump. The objections may be said to be either due to the lost power required for this transfer, the increased weight and size of the pumping unit and the more frequent attention. In some cases, toothed gearing is found to be objectionable on account of the noise.

The accompanying illustration shows a General Electric direct current motor driving a Knowles pump operated on this principle. The pump and motor are mounted upon a rigid box girder frame and the unit is self contained. The plungers of the pump are 3½ inches in diameter and have a stroke of 5½ inches. They are directly driven by a 6 pole direct current shunt motor of 100 horse power capacity, operating at a voltage of 220, running at a normal speed of 280 revolutions per minute. When running at this speed, the pump has a capacity of about 250 gallons per minute against a head of 1000 feet.

The use of electrical driven pumps have many advantages especially when the pump is to be used at some distance from



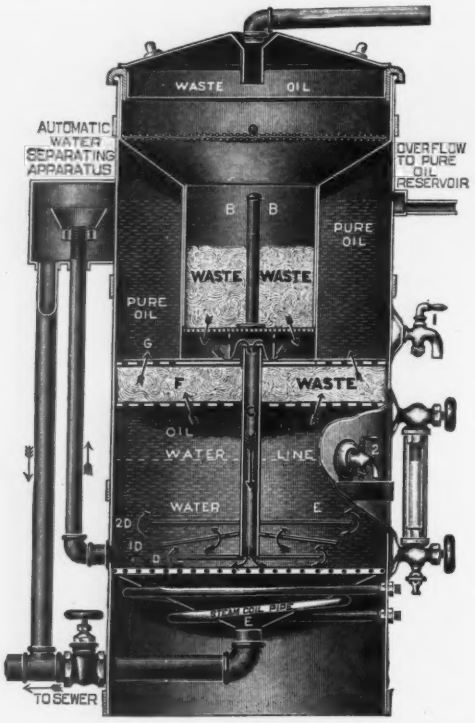
the power plant. The use of steam for driving pumps at a distance is objectionable on account of the loss of condensation, the expensive piping and the numerous joints liable to leak. Compressed air is sometimes used for this purpose but since a unit of this kind only requires two wires to be led to the place where it is required to be operated, it has especial advantages for use in mines.

One objection to this style of unit is the fact that on account of the comparatively slow speed required of the motor, it requires a larger motor than would be required when the machine is speeded up and geared down to the required speed of the pump.

### An Oil Filter.

The accompanying illustration shows an Oil Filter, Style B, which is manufactured by the Burt Manufacturing Co., of Akron, Ohio. This filter takes the condensation from oil separators and exhaust heads and automatically separates the oil from the water and at the same time purifies the oil, the absolutely pure oil going into the pure oil reservoir and water running from the drip into the sewer.

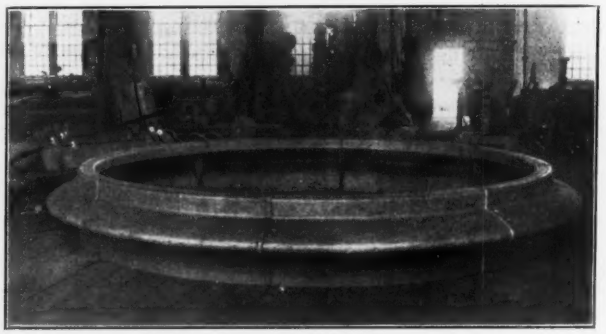
Referring to the accompanying cut, it operates as follows: The oil and water is poured in the top of the filter and passes into chamber B, through the layer of waste, which collects the heavier impurities of the oil. The mixture then goes through the perforated bottom of chamber B, down in the direction shown by the arrows into tube C, and from here on to the filter plate D, where the increased weight of the water has a tendency to keep the oil back, in tube C. However, the pressure of oil in chamber B forces it down and spreads it out over plate D, in a very thin film, which constantly changes surface and grows thinner as it travels from the centre to the circumference of plate D, thus exposing every particle of waste oil to the action of the water. It then flows up plate 1D and 2D, going through the same process in each case. When the oil leaves the filter plate 2D, it is in a finely divided state of separation and thoroughly mixed with the water which washes it out and from which it separates by gravity all the remaining impurities which settle in chamber E and can be removed by opening the gate valve at bottom of filter, which drains off all the water and dirt. From plate 2D the oil again filters through the stratum of filtering material, F, and from there it rises to the pure oil chamber and then flows to the oil reservoir. The water is automatically separated from the oil after it passes down the tube C and reaches the bottom plate, as the oil is lighter than the water, and just as soon as it reaches the bottom of the filter, it immediately rises and the surplus water passes into the tube which leads to the automatic water separating device.




Before the introduction of oil filters, all cylinder oil went to waste and as the cylinder oil is the most expensive oil used around a plant, the saving effected is considerable, as this reclaimed oil can be used to lubricate pumps and other machinery. These Filters are made in several sizes from 3 to 500 gallons capacity per day and are sent on 30 days' trial to anyone wishing to try them.

### Castings for the Largest Steel Stacks in the World for the Pennsylvania Railroad Tunnel Power House.

Eight large castings have recently been finished by the Kutztown Foundry and Machine Co., of Kutztown, Pa. These castings, shown in the accompanying illustrations, are to be used in the construction of four large steel stacks at the Pennsylvania Railroad tunnel power house at Long Island City. These stacks, when completed, will be the largest steel stacks ever erected in this country or abroad.



Top Casting of Chimney, 19 feet in diameter, weighing 9000 pounds.

The power house will have four of these enormous stacks, each of which will be 275 feet high above the iron base plate, the diameter at the bottom of each stack being 23 feet 4 inches and the diameter at the top 16 feet 9 inches. The chimneys are composed of steel plates ½" thick at the bottom and 5-16" thick at the top, lined with brick. The total weight of steel used in the four stacks is about 1000 tons.

The casting for each base plate alone weighs 24,000 pounds, the outside diameter of which is 25 feet 2 inches. The bottom casting is made in 10 sections, machined to fit. The top casting has an outside diameter of 19 feet and weighs between 8000 and 9000 pounds. It is made in 8 sections with machined

Base Plate Casting of Chimney, 25 feet 2 inches in diameter, weighing 2400 pounds.

joints. The Kutztown Foundry and Machine Co. make a specialty of casting for chimneys but these are by far the largest that were ever made by them.

The great central power house, in which these stacks will be used, will generate the power for the Pennsylvania Railroad trains which will run underneath the river between Jersey City and Long Island. This power house will contain a number of 7500 K. W. Parson-Westinghouse turbo-generators which will have an overload capacity of 11,000 H. P. These turbines will use steam at a working pressure of 175 pounds per square inch. The steam will be superheated from 100 to 175 degrees and after leaving the turbine it will be condensed.

The tunnel beneath the Hudson river will be driven through a strata of silt whose consistency is so very uncertain that it will have to be supported by artificial means to prevent displacement either in a vertical or lateral direction. The tunnel will be treated as a trestle bridge resting on cast-iron piles at 15 foot intervals and supporting the track system above them, the shell of the tunnel serving as a protection to the trains. The piles are to be hollow, 27 inches in outside diameter with 1½ inches thickness of shell and they will be made in 7-foot sections. At the foot, the piles will be provided with one turn of a wide screw of 12" pitch. These will be screwed down through a hole in the base of the tunnel shell until the underlying rock is reached.

In order to screw the pile down, a hydraulic screwing machine will be used. It will consist of two cylinders attached to a frame and furnished with differential plungers 11½" and 10" diameters by 18" stroke. A hydraulic jack is used to press the pile down, while the hydraulic screwing machine does the turning. The test pile driven by this method was subject to dead load tests, which occupied a period of 5½ months. During the last part of the test, it stood a dead weight of 600,000 pounds without subsidence.

### An Emergency Steam Trap.

A trap, which has all the advantages of discharging a large amount of water in cases of emergencies and which does not waste steam under ordinary conditions, is built by the Wright Manufacturing Co., 72 Woodbridge St., Detroit, Michigan. It is said of this trap, shown in the accompanying illustrations, that it never becomes "badly rattled" when an excessive amount of condensation must be disposed of and for this reason shows its worth in cases of emergency.

To accomplish this result, three steam tight outlet valves are employed instead of one, the operation of these three valves being as follows: The condensation enters the trap and fills it to about the centre. This water of condensation covers both the inlet and outlet of the trap and prevents any possible escape or waste of steam. When thus filled, the float rises and opens the centre valve, marked No. 1 in Fig. 2, which represents an enlarged view of the valve arrangement. This first valve is capable of taking care of all the water of condensation under ordinary circumstances, but should the water come into the trap faster than one valve can discharge it, the water rises in the trap, carrying the float with it and opens a second valve either sufficiently to discharge the surplus water or wide open if necessary. The third valve is opened in the same manner, providing for the full capacity of the inlet pipe. All three valves are of equal area and the fact that two of them are reserved for emergency use makes this trap practically three traps in one. The discharge from each of these valves is not intermittent but continuous, making the capacity of each a maximum.

The valves are located at the highest point of the trap, away from grit and scale and are very accessible. In case they do require attention, it is only necessary to remove the iron plug over the tube with a wrench and the valve seats can be taken out with a screw-driver in a short time. Other working parts are reached by taking off the lid of the trap, which does not disturb any of the pipe connections.

The valves and valve seats are constructed from steam jet metal. A round seamless copper float of special construction

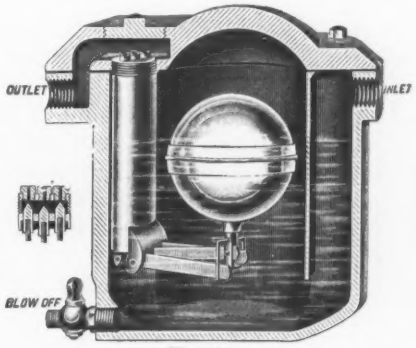


Fig. 1.

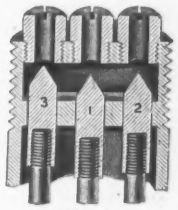


Fig. 2.

is employed, being reinforced so that it will not collapse. Water gauge and gauge glass are provided with which the operation of the trap is always visible. The blow-off valve, which is screwed into the lower part of the trap, provides for the removal of sediment as often as necessary. These traps are guaranteed to operate successfully on varying steam pressures up to as high as 250 pounds per square inch and no special adjustment or change of valves is required for different steam pressures, which makes it perfectly automatic. Fig. 1 shows a sectional view of the trap from which its operation can be clearly seen.

### The Coming N. A. S. E. Convention.

The Twenty-third Annual Convention of the National Association of Stationary Engineers will be held in Richmond, Va., August first to sixth, inclusive. About six hundred delegates and members are expected to attend.

The exhibition of supplies will be held in Richmond Armory, bringing all exhibits together in one large hall, insuring ample space and equally desirable position for every exhibit.

There will be something besides the exhibits to attract visitors to the Exhibition Hall. Many of the most attractive numbers on the entertainment program will be given there, and the exhibits will get more attention from the delegates and visitors than at any previous convention.

The National Supply Men's Association will have entire charge of the entertainment and exhibits, and will pay all bills. There will be a uniform contribution of $25, which will entitle the contributor to space for exhibit without further charge.

Headquarters will be at Murphy's Hotel. Rates $2.50 to $3.00 per day, American plan. G. W. Sly, World Building, New York, will furnish any further information desired.

### Steam Turbine Tests.

The testing of steam turbines for efficiency is being carefully investigated in this country, chiefly as applied to the direct driving of electric generators. Large machines of this type are said to give a very good efficiency, while small sizes seem to have as good an efficiency as can be obtained by large reciprocating engine plants and a great deal better than correspondingly small piston engines. This enables electric generating plants to be divided into small generating units, giving great flexibility and variation of service in the employment of such independent units, as compared with a large central generating station and with apparently as good efficiency as in the large case.

For instance, the lighting of forty-seven underground stations on the New York Underground Railroad is done by three turbine motors of 1250 kilowatts capacity directly connected to three-phase generators.

The efficiency by tests of these comparatively small installations appears to be about 14½ lb. of steam per electrical horse-power, which, of course, tends to increase to 16 lb. at half-load, and to 19 lb. at quarter-load, which are results quite comparable with larger installations with piston engines of the best design and large capacity. In larger concentrated intallations of turbine-driven generators, so low a consumption as 11¾ lb. of steam per electrical horse-power has been guaranteed, which, as it is equivalent to about 10¾ lb. per indicated horse-power, may be taken as a most excellent efficiency, comparable to any of the best reciprocating engines.

In a direct comparison with a small generating plant at Hartford, Conn., it was found that under service conditions, a turbine steam motor could deliver 1900 kilowatts at the switchboard for the same amount of coal that was required by a steam piston engine to deliver 925 kilowatts at the same steam pressure and at the same vacuum. In another test for so small a plant as 400 kilowatts the steam consumption for the turbine motor was only 16½ lb. of steam per electrical horse-power per hour, with 125 lb. steam pressure, and 27-inch vacuum, and this only increased to 18¼ lb. for half-load.

It may be noted that steam super-heated to almost any extent can be used with ease in the turbine motor, as there is no trouble with the lubrication of valves and pistons as in the piston engine, and owing to absence of internal oiling in the steam turbine, the condensed steam may be returned to the boiler without danger.

### A World's Record in Coal Hoisting.

The steadily increasing bulk in which coal is conveyed by sea and rail, and stored for boiler service in high pockets at power stations and plants, has led to a demand for increased speed in the necessary hoisting and handling machinery. Demurrage on steamships and cars is an item to be carefully avoided in economical management, and the large cargoes now shipped to terminals can only be handled with success by specially designed high speed machinery. The problem is different from, and more difficult than, the familiar one of bulk unloading and storage of coal, ore or similar materials on the ground level from vessels. The element of height materially affects the machinery design. With a single tower, hoisting to about fifty feet above tide water, forty to sixty tons an hour was, until recently, the common speed, and ninety to one hundred tons was only attained with difficulty in exceptionally favorable circumstances.

The work demanded of coal hoisting towers and their machinery is of the hardest description, both from the unskilled nature of the labor employed, and the shocks to the machinery incidental to the service, and it changes constantly with the nature and size of the coal, which may vary from a soft pea variety contained in open wooden barges, to a hard foreign product in cubes, two feet square, loaded in steel vessels with small hatches. A great advance in the speed of handling coal from freight vessels and barges, has been made a world's record for rapid unloading having been recently established at the Lincoln Wharf Station of the Boston Elevated Railway Company.

Run of mine bituminous coal was raised ninety feet above the tide water from one hatch of a vessel and delivered to the storage pockets, cracked to mechanical stoking size, at the rate of three hundred and twenty tons per hour, by one tower. This is an advance of about two hundred per cent. upon the previous best, and marks an important mechanical engineering achievement.

To attain this end, the steam engines of fifty to one hundred combined horse-power in common use have been replaced by machinery of three hundred horse-power, and the coal cracking machine attached to the tower cracks to the proper dimensions for automatic stokers, before passing to the pocket the enormous quantity of coal, over five tons per minute, delivered to it from the hoisting machinery. The ordinary small steam shovel has been supplanted by an automatic one of two tons capacity at each lift.

The time occupied in raising two tons of coal from the hold of a vessel to the discharging hopper, nearly one hundred feet above, is only six seconds, while the round trip, involving the operations of lowering and moving the shovel out of the boom, opening the former, digging up two tons of coal, raising it to the level of the hopper and discharging it therein, is frequently performed in twenty-two seconds. The moving gear and coal cracker is electrically driven and the hoisting engine direct connected. The towers have to traverse overhead the whole length of the coal storage pocket and to move thirty feet at a time without changing steam connection. In this way a single tower can operate on each hatch of a vessel in turn, or several towers can work simultaneously.

### A New Council of Engineers.

A new council of the American Order of Steam Engineers was instituted at Alliance, Pa., on Tuesday evening, May 31. The ceremonies were conducted by Supreme Chief, Hiram Trout, assisted by Supreme Chaplain, A. P. Dreisbach. The new council will be known as Cement Council, No. 23.

The following is a list of officers elected to fill the chairs for the first term: Chief Engineer, B. C. Wilson; Asst. Chief Engineer, Harvey Shellhamer; Sr. Master Mechanic, Wilson Lauer; Jr. Master Mechanic, Christian Smith; Chaplain, Reuben Ott; Inside Sentinel, Titus Guth; Outside Sentinel, Morris Moyer; Recording Engineer, John H. Hess; Financial Engineer, James Lentz; Treasurer Engineer, Wm. H. Thomas; Past Chief Engineer, H. T. Raisbeck; Trustees, Wm. D. Coleman, Chas. Silfies, Albert Beers.

Following the installations, the new council tendered a banquet in honor of the Supreme Chief and visiting members of the order from Allentown.

## Noon Hour at Powers' Mill.

PART IX.

By A. Edward Rhodes.

We were eating our dinner, setting around on boxes, boards, and benches, when someone began talking about getting jobs. Say d'ye see the cub what struck the boss fur a job this mornin? asked Dennis, who is popular with the employees of Powers' Mill more because of his unconscious ability to entertain us by his arguments, than because of any natural desire, on his part, to do more work than is required for him to hold his job in the fire room. Y'es dident see him? No! Well he came in while Misther Powers was busy and out of temper because the kid over ther don't know how to run a engine an keep her main boxes from gettin outen line. Well he comes in as big as life an says to Misther Powers, says he, Misther Powers, I wants to be a stathionary ingineer, an I am old enough to begin learnin now. The boss never let on he heard a word but jist went on a measurin an fussin around among some papers he had at his desk, an finally, after some figitin around, the boy says, Misther Powers I am in a hurry please, for school begins at nine o'clock an I don't want to be late, an I want a job sir. Don't believe we got any work for you, said the old man a kinder bluffin him off like, jist to see if he had any "stick to" in him, for you know he wants a bright boy to take the place of that fresh kid he fired last week. Oh but you surely can find work for me to do, an I will come on trial if you will have me. I hain't afraid of work.

At this Misther Powers began to weaken, and says when can you come to work. Why says the boy, I can come this afternoon. I will go to school an tell the teacher that I am leaving school to go to work, and then go home and get some old clothes and overalls. All right; come this afternoon, an he was hired quick as that; an says Misther Powers, a turnin round to me, Dennis I'll bank on that boy, he's got sand enough and is not impudent either, but knows what he wants and how to go about gettin it. The prime requisite for success in any undertaking. Yes, says Charlie (commonly known as the Kid), I am willing to bet that boy won't be three months in this mill before he joins one of the night drafting classes or else becomes a student in one of the correspondence schools, which by the way, have wrought a greater change in shop methods than any one factor that has entered into the several causes that have made conditions what they are in the shops and factories to-day. We hear a great deal about shop owners requiring a higher standard of efficiency to-day than they did a few years ago. Why? Shure an I know and its the men themselves as did it. Dont each one av us be ambitious to get the best job in the shop and get to be a boss some day, answered Dennis. Yes and when you get to be boss Dennis I'll resign and hunt another job. No you wont resign ither; I'll fire ye.

As I was a-sayin: ivery man in the shop is thinkin "I need a bether technical edication" and we all begin to study, some more as ithers, by in by, we git to be pretty good at figgerin and drawin an we git a job in the draftin room makin tracings an blue prints, and then are a draftsman's. Them of us, like meself what is too thick-headed to git beyond figgerin how much pay I git when I don't lose any time, we stay a workin in the shop, an of course, we are smarter than the fellow what don't know as much and niver did study the technical side of the enginerin perfession.

Boys I think Dennis is right, said Mr Powers who just came in and overheard a greater part of the conversation, I don't know if any of you noticed the boy that was in the office waiting for me when the whistle blew at noon, anyhow he had on a bad attact of that tired feeling when he asked me for work. I said "I dont believe we have enough work just now to keep you busy. It wont take much work to keep me busy, he replied. Then I said, I do all of that kind of work myself that you want to do. To which he said: Then this is just the kind of a place I want. I love to watch other people work, and tried to be funny. I tell you men, when a man wants a job he must not smell like a brewery, neither can a boy whose fingers and lips have the sickly yellow look that means cigarette nerves get work in any self-respecting factory. To be brief it means that a man or boy to get a job must approach the employer in a way that is convincing as to the man's sincerity, his appearance must suggest ability and indicate the gentleman. And Mr. Powers goes out and leaves us. I agree with Mr. Powers, as far as getting a job goes, but after he has the job, I contend a man, these days, is required to have more or less of a technical education, and further that the man who devotes, say, half an hour daily to the study of the theoretical side of his trade stands a better chance of getting and holding a job than one who is satisfied to start work after the last blast of the whistle and stop at the first, like a certain man in this mill who I have seen with a wrench in his hand drop it, right where he was, at the first toot of the quitting time whistle; and then walk right on and past the place he was going to put the wrench, had the whistle blown but half a minute later. To me an action of that kind don't seem fair to the man that had the wrench, to the wrench, or to the employer.

Now see heer Kid, thots not agivin me a fair chan'st fur the whistle is now ablowin, jist like you, and I can't refute the sayin, only we all know ye are a fair days work for a honest days pay crank. An fut ye may say don't make me luve woruk any more than I did, be-gob.

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## Properties of Graphite.

Graphite is one of the purest forms in which carbon occurs in nature. It possesses a bright lustre and is very smooth and soft. It is unaffected by heat or cold and is not acted upon by acids or alkalies. It has a strong attraction for the metals and when rubbed on them forms a surface of great smoothness. As all bearings are more or less rough, the advantages of graphite as a lubricant lie in the fact that it fills up these small uneven places and makes them smooth and mirrorlike, so that when oil or grease is used, it relieves them of this service which they would otherwise have to perform, making lubrication more effective and increasing the wearing qualities of the oil. When used in cylinders of steam engines, either alone or with oils, it tends to polish both the valve seat and the interior of the cylinder. It is especially valuable when high temperatures are encountered, as in the cylinder of a gas engine, where temperatures as high as 3000° F. are met with. It can be fed into the cylinder of an engine in the usual way or by means of a hand pump, several times a day. Force feed lubricators offer the best means of insuring a steady, closely-regulated supply of graphite, mixed with oil or water, to either cylinders or bearings. When mixed with grease, it can readily be used in any compression grease cup.

## TRADE NOTES

Owing to the largely increased business of The Republic Rubber Company, Youngstown, Ohio, in their specialties—Searchlight Sheet Packing, Cross Arm Tubular Gasket and Firestone Piston Packing, the Company has opened a store at No. 116 Lake Street, Chicago, Ill. This store is one of the handsomest rubber depots in the country; finished throughout with quartered oak; large display windows beautifully lighted with prism glass show their goods to advantage. The Western Sales Department will be conducted from the Chicago office, and will be under the management of Mr. J. H. Kelly. The Company advise us of a heavy increase in all branches of their business, and in one department are running full force twenty hours a day.

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If your belts slip, send for a sample stick of the Practical Belt Stick, made by the Practical Manufacturing Co., Richmond, Ind. Mention THE PRACTICAL ENGINEER.

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It is the custom of many to deride testimonial letters, and sometimes justly, but before doing so one should always read and consider. Any appliance that is recommended by nearly every purchaser must possess unusual merit. The most fortunate person that we know of in this respect is Frank A. Simonds, 421 Houseman Building, Grand Rapids, Mich. Mr. Simonds has received scores of letters from users of his patent receiver and separator, all praising it in the highest terms. One of the latest letters is from Belding Bros. & Co., Belding, Mich., who set forth the conditions in their plant and tell of extreme vibration of the main steam line and also of trouble with rushes of water to the engines, which the Simonds apparatus has overcome. Another letter is from Hockensmith Wheel and Mine Car Co., Penn Station, Pa., who seem to be equally well pleased.

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Fans! Ah, that's the thing. The fan man and the ice cream man are equally popular these days, especially in hot engine and boiler rooms that have mighty little ventilation. A good fan, stuck in a window and belted to a convenient shaft costs next to nothing and makes a great difference in the temperature. Joseph Carr, 132 North Seventh street, Philadelphia, is the manufacturer of the best fan made for this purpose.

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A leaking gauge cock always reflects upon the integrity of the engineer, yet there are many leaking gauge cocks to be found, and the principal reason is because the engineer fears to order a new one lest it will soon be as bad as the old one. But there is one now that's different. The "P. B. H." weight gauge cock seems to be very near perfection. The weight keeps it always closed and the metal valve pencil is a guarantee against leaks. One will be sent for free trial upon request. Address Paul B. Huyette, 2045 Betz, Building, Philadelphia.

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Manning, Maxwell & Moore have opened a handsome new store at 721-723 Arch street, Philadelphia, where they display an excellent line of machine tools and steam specialties, including the Taber indicator, Metropolitan injectors, Hancock inspirators and Consolidated Pop Safety Valves. Engineers, and especially machinists, will find much there to interest them. The new store is under the management of Mr. George E. Randles.

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The Stephenson Manufacturing Co., Albany, N. Y., have received a letter from F. E. Soule, Superintendent of J. G. Downward & Co., Coatesville, Pa., as follows: "About one year ago you sent me a sample bar of your Belt Dressing, which gave such remarkable results that the trial was followed by an order for a case. This order was duplicated this season through a Philadelphia dealer. I have tried a great many standard belt dressings, and on account of the dust, grit and uneven strains on our belts always had trouble, having to run them very tight, thus causing unnecessary friction to the bearings (and as nearly all our mills are of necessity placed on one side of main-line shaft) and having a tendency to gradually pull shafting out of line. Belts were also constantly slipping and belt lace holes pulling out.

"Since using your 'Bar Belt Dressing' I am running belts extremely loose, in all places, have no trouble with belts slipping or jumping off, have a great saving in friction, thus saving fuel, etc., and am getting deal higher efficiency from my mills. For a dusty place, uneven loads, or in fact any place where conditions are very severe I would say, 'Use Stephenson Bar Belt Dressing.' I have every belt in the place treated every morning. This lasts all day."

---

Away back in 1842 the Nason and Sidelug steam traps were put on the market, and they are still there, which fact is sufficient proof that there is something good about them. There is also something good about a new illustrated circular which the manufacturers of this interesting old trap have just issued. It shows the construction of the trap and tells about the efficiency which it has given during all these years under all sorts of conditions. Write for one to the Nason Manufacturing Co., 71 Fulton street, New York.

---

The American Injector Co., Detroit, Mich., have issued a new book, entitled "Our Engineer's Red Book," a copy of which will be mailed free to any engineer mentioning THE PRACTICAL ENGINEER.

---

The "Gladiator" patent combination gaskets, manufactured by the New Jersey Asbestos Co., Camden, N. J., have two concentric rings made from asbestos metallic cloth, which are sustained by a metallic ring with a vertical wall in the centre, which forms a partition between them and prevents their displacement by steam or moisture, making them suitable for the highest steam pressures, and insuring long service.

---

Five hundred articles, including everything that an engineer could use from an oil can to an indicator, are being given away as premiums with the famous "Steam Stopper" brands of metallic and fibrous packings, made by the France Packing Co., 6514 State Road, Tacony, Philadelphia, Pa. Write for catalogue and list of premiums.

---

A ninety-six page booklet containing a wealth of information about the purification of boiler feed water and the prevention of scale and corrosion will be mailed free by the Lake Erie Boiler Compound Co. to any reader mentioning THE PRACTICAL ENGINEER.

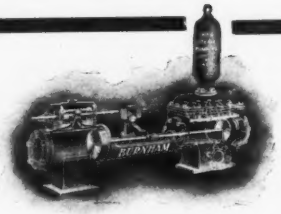
---

About the meanest job on earth is to crawl inside a fire tube boiler and knock scale off the tubes with a hammer. With a TORPEDO cleaner this mean job can be accomplished from the outside with comparative ease. The makers of this interesting little device offer to send one for a "free try, if you no like me, no buy." That seems fair enough. Write for one to The General Specialty Co., 75 Carroll street, Buffalo, N. Y.

---

Every engineer or user of steam, who attends the St. Louis Exposition, will, of course, be interested in the Steam, Fuel and Gas Building, in which is located the immense boilers of American, French, German and English manufacture, in all some forty thousand horsepower, which furnishes steam for power and other purposes for the entire Exposition.

The most improved and modern type of boilers can here be seen, as well as the most improved and modern boiler room equipment. Not the least interesting display along this line is that made by the Lagonda Mfg. Co. of Springfield, Ohio, who have a space 15x20 feet, di-




Union Steam Pump Company

BATTLE CREEK, MICHIGAN

Manufacturers of the

GREAT BURNHAM

STEAM PUMP

The Pump that won't short Stroke.

rectly in front of and midway of the line of boilers referred to above.

They have a very attractive display of their entire line of Tube Cleaners, and other Boiler Room and Steam Specialties, and the representatives in charge will take pleasure in showing these machines and devices to anyone that may be interested, and they can also be seen in practical operation in the boilers.

Don't fail to call at the space of The Lagonda Manufacturing Co., make yourself at home, rest your body and watch their Cleaners demonstrate their superior merit in actual use.

Make the place your headquarters; you'll also find a handsome souvenir, which may be yours for the asking.

---

Messrs. Adam Cook's Sons, 313 West street, New York City, the only makers of Albany Grease, claim that the use of their well-known lubricant will save one-half of the oil bill. Testimony received from engineers who have used Albany Grease show even a larger saving than this. Allan S. Ferry, engineer of the Locomobile Company of America, writes from Bridgeport, Conn., as follows: "We are using Albany Grease on our three air compressors and since using it our oil bill has been reduced at least seventy-five per cent. and the machines are better lubricated than ever." Any engineer or steam user can get a free sample can of Albany Grease and a cup free of charge by writing to the above address.

---

A picture taken in Madras, India, showing some electric poles of peculiar construction and also a large shipment of Lord's Boiler Compounds, loaded on novel vehicles pushed by natives, will be mailed free to any reader of THE PRACTICAL ENGINEER upon request. This picture should be of interest to any one interested in pole construction. Address George W. Lord Co., 2238 North Ninth street, Philadelphia. The Lord Co. also offer to send a nice rule free to any engineer who sends them a sample of scale from his boilers for free analysis.

---

**WANTED.** Local agents in all parts of the Country to sell WILLIAMS STEAM SPECIALTIES. All familiar and connected with power plants can largely increase their income. Many are building homes by selling our goods. Engineers and others are doubling their incomes in their spare time. **Our goods reduce fuel bills,** and appeal strongly to those who pay the bills, and repeated orders is **the rule. Write us** at once for full information.

**THE WILLIAMS GAUGE CO.**
**543 Fourth Avenue - - Pittsburg, Penna.**

---

**IF ENGINEERS** will send $1.00 to the address below they will receive two blue prints, with tables and instructions, showing how to set valves and eccentrics on Corliss engines, simple and compound, with one and two eccentrics.

JOHN T. LINDSTROM,
214 and 216 S. 3d St., Allentown, Pa.

---

**Wanted** ENGINEERS... AND SALESMAN
To handle France "Steam Stopper" brands of Metallic and Fibrous Packing as a side line. Good inducements to right party. Address
**FRANCE PACKING COMPANY, TACONY, PHILA., PA.**

The Nason Manufacturing Co., of 71 Fulton street, New York have just issued their 1904 catalogue of their general supplies, which is devoted exclusively to all-iron appurtenances used in connection with ice-making and refrigerating machinery. It is a particularly valuable catalogue to anyone using this kind of machinery, as this firm has grown up with the ice-making industry, and their intimate knowledge of the requirements enables them to supply you with just what is needed in all kinds of ammonia valves, cocks and fittings, condensers, coolers and other fixtures and accessories of this kind of plant. Write for catalogue.

---

This is an age of specialties. Business is getting so large that many firms put their best energies into a few specialties and perfect them. The Foster Steam Specialties are perfection in their line. Their valves are fine for regulating high and low delivery pressures. Their pump governor governs, their back pressure valve does not chatter, and their other steam specialties are equally as good. The Foster Engineering Co., Newark, N. J., are the manufacturers.

---

Larkin's Packing is a combination of the finest prepared granulated metals, incorporated with graphite, and placed in cotton tubes. These tubes are placed in the stuffing box like ordinary soft packing, and when compressed by the gland form an accurate ring, which it is claimed will last as long as the engine. The makers of this wonderful packing are Pennsylvania Electrical and Railway Supply Co., Pittsburg, Pa. Write for descriptive booklet, mentioning THE PRACTICAL ENGINEER.

**Let us put it before you plainly.**

Say the cost of oil at your plant is $300 per annum. If you used a

**CROSS OIL FILTER**
you would
**Save one-half the cost of oil**
or $150.00 which is the interest at six per cent. off $2500.

Don't you think it is worth while to order a Cross Oil Filter to-day? The Filter is sent, anywhere on thirty days approval.

"So far as we are aware The Cross Oil Filter is the most satisfactory filter on the market." — St. Louis (Mo.,) Portland Cement Co.

**THE BURT MFG. CO.**
Largest Manufacturers of Oil Filters in the world.
**204 Main St., Akron, Ohio, U. S. A.**
Also supplied by Oil Companies, Engine Builders Dealers, and Power Contractors.
**FAIRBANKS CO.**
Sole Agents for Philadelphia.

---

**NEW BOOKLET UPON AN OLD SUBJECT.**

**Oil vs Grease**

With especial reference to an interesting discussion.

**Dixon's Graphite Greases**

Copies upon request.

**JOSEPH DIXON CRUCIBLE CO.**
**Jersey City, N. J.**

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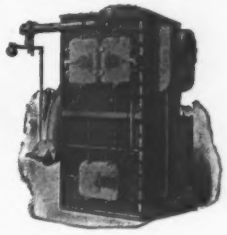

**Utilizing Exhaust Steam**

After your engines have converted into work the very small per cent. of the heat in the steam that can be utilized in this way, what do you do with the exhaust steam that leaves these engines? This exhaust steam (in the case of non-condensing engines) contains from 90 to 95 per cent. of all the heat that the live steam had when it left the boilers. There is one way in which a large part of the exhaust steam can be utilized—send it into a

**COCHRANE HEATER**

Having made provision for heating the boiler feed supply, the remaining exhaust steam can be utilized in the Cochrane Heater for heating any water that may be required for other purposes, or it can be used in an exhaust steam heating system.

If you will tell us what your conditions and requirements are, we shall be glad to tell you what a Cochrane Heater can do for you, at the same time submitting detailed specifications and prices, recommendations and guarantees.

Send for our **Catalogue 16-H**

**HARRISON SAFETY BOILER WORKS**
**3144 N. 17th Street**
**PHILADELPHIA, PA.**

Manufacturers of Cochrane Feed Water Heaters, Cochrane Steam and Oil Separators and the Sorge-Cochrane Systems.

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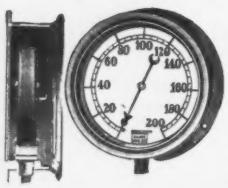
**"STANDARD" SELF CONTAINED GAUGE**



We claim particular merit for our gauges and mention several of the numerous points of superiority.

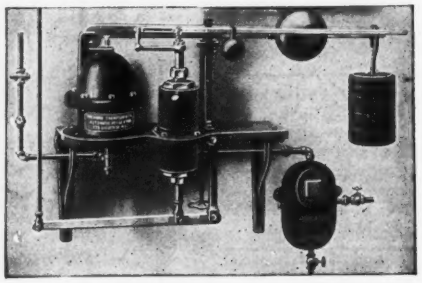
Mechanism is independent of case.

Material used is selected on account of having wearing qualities that will outwear two gauges of stock generally used.

They are non-corrosive, attractive and accurate.

Send for our catalogue, which illustrates and describes Gauges of our manufacture for all known purposes; Engine Counters, Clocks, etc.

**STANDARD GAUGE MANUFACTURING CO.**
107 N. Franklin Street, Syracuse, N. Y., U. S. A.
New York Office, 141 Broadway Chicago Office, 58 Washington Street
**PACIFIC COAST AGENTS,**
Geo. H. Tay Co., San Francisco and Los Angeles, Cal., Seattle, Wash.



The Thompson Damper and Pressure Regulator with latest improvements, insures uniform steam pressure and must

**SAVE COAL.**

Indicators, Reducing Wheels, Planimeters, etc.

The Soot Ejector and Injector Blower, Boiler Tube Cleaners. Shaking, Dumping and Stationary Grate Bars.

**RICHARD THOMPSON & CO., Sole Manufacturers**
**128 LIBERTY STREET NEW YORK, N.Y.**

There Must Be Some Reason

**WHY**

# Homestead Valves

**are demanded in all four quarters of the globe**

We will impart the secret to you. They are higher priced and very much better than the ordinary kind for all *HARD-TO-FILL* places.

Write for Booklet No. 10, just issued.

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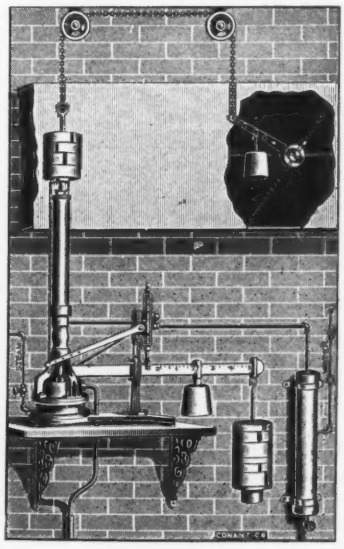
**Homestead Valve Mfg. Co.**

Box 1754, Pittsburg, Pa., U. S. A.

**Works at Homestead, Pa.**

**Locke Damper Regulators.**

**8000 Sold Since 1886.**



Regulators for Sugar Refineries, Paper Dryers, Drying Cans, Dye Houses.

We Succeed Where All Others Fail.

Catalog Upon Application

Prices Greatly Reduced.

Sent Anywhere on Thirty Days Trial.

**WM. E. BENSON & CO.**

**1001 Chestnut Street, Philadelphia, Pa.**

# Don't Go CRAZY

using poor packing—making it necessary to repack the stuffing box every week or so. Had you decided, before the hot weather began, to

## Use P. P. P.

you could enjoy all your Sundays and take it easy during the week, as the box would need no further attention for months. It isn't too late to enjoy the remainder of the summer. Begin using P. P. P. to-day. Write for our free booklet on friction.

**Quaker City Rubber Co.**

**PHILADELPHIA AND CHICAGO.**

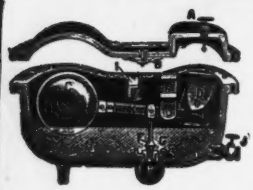
# The Tornado Boiler Tube Cleaner

Requires LESS steam than any other cleaner.
Will positively clean BETTER than scraper or brush.
Will clean ANY length tube.
In operation EQUALLY balanced, insuring NO back pressure against operator.
Is the LIGHTEST and EASIEST cleaner to handle.
Has NO working parts.
Its force is tremendous.

**Manufactured** by

**Paul B. Huyette**

1245 Betz Building
Philadelphia



# McDaniel Steam Traps

Always have a Water Seal over the valve and never blow steam; neither do they back up water

REDUCING VALVES
EXHAUST PIPE HEADS,
EJECTORS, RELIEF VALVES,
GREASE EXTRACTORS,
STEAM SEPARATORS, etc.

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For sale by the Jobbing Trade

# CRANE VALVES

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**Steam Coal a Specialty** **Telephone Connection 2-25-66**

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# U-NEED-A CLIMAX DAMPER REGULATOR

MANUFACTURERS OF

Reducing Valves and Steam Traps for all services, Damper Regulators, Back Pressure Valves, Relief Valves, Boiler Feeders, Grease Extractors, Steam Separators, Float Valves, Hot Water Tank Temperature Controllers, Water Feeders, Tank Pump Controllers, Water Arches, Pump Regulators, Waste Heat Utilizers, Automatic Receivers and Pump Regulators, Combination Muffler Tanks, Grease Extractors, etc.

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**KIELEY & MUELLER**

34 West 13th Street, NEW YORK CITY

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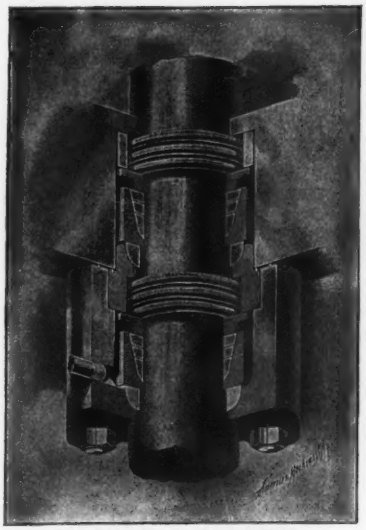

CLASS No. 1 PACKING

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## Piston Rod and Valve Stem
# PACKINGS

Do their work well.
Their use will save you considerable money and endless trouble.
We can present convincing proof of their worth.

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## The United States Metallic Packing Co.

MAIN OFFICE AND WORKS:

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CHICAGO. ILLS.

No. 427 North Thirteenth Street.
PHILADELPHIA. PA.

Dirty roofs and walls give your plant an unbusiness like appearance.
Neatness in this respect can be secured at a comparatively small expense.

# The Sterling Exhaust Head
## Will do it Perfectly

No back pressure on your engine.
All the water and grease in the steam entrapped and drained to any desired point.

WE PREPAY THE FREIGHT.
YOU RETURN THE HEAD IF NOT AS REPRESENTED

## Sterling Pipe and Blower Company

HARTFORD, CONN.

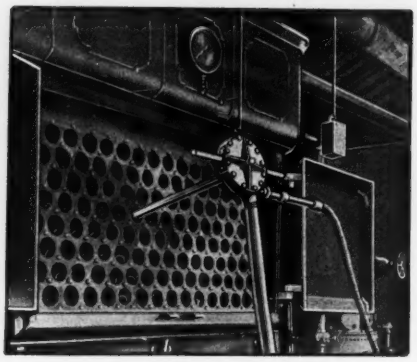
YOU'LL DOUBTLESS BE GOING TO

# The St. Louis Exposition

and if interested in Boilers and Boiler Tube Cleaners
will want to see **THE BEST,** and that is of course

# THE WEINLAND

No. 8 Turbine, Patented.



Direct Motor, Patent Applied For.

You'll find it on Exhibition in Steam, Gas and Fuel Building, where different types can also be seen at work on the several styles of boilers (40,000 H. P., U. S. and Foreign make) there used for supplying steam for power and other purposes for the entire Exposition.
Don't fail to call at our space ; make yourself at home ; rest your body and watch our cleaners

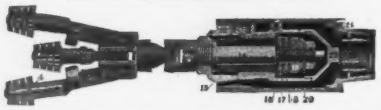
**DEMONSTRATE THEIR SUPERIOR MERIT IN ACTUAL WORK.**

You'll also find at our Exhibit a full line of our Boiler Room and Steam Specialties, and we'll have a souvenir for you. too.

**The Lagonda Mfg. Co.,**

Boiler Cleaning Experts,
SPRINGFIELD, OHIO.

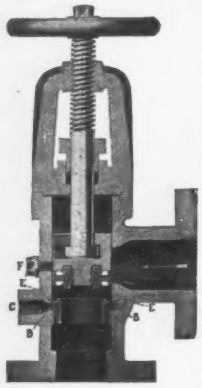
# Boiler Tube Cleaners
# Blow-off Valves



## The Liberty Turbine Boiler Tube Cleaner

will clean tubes more thouroughly, at less cost, and in less time than can be done by other means.

**This we guarantee.**



We also make the **Niagara Turbine Tube Cleaner.** We have suit for infringement of patents against a user of the Weinland machine, and will sue all other infringers

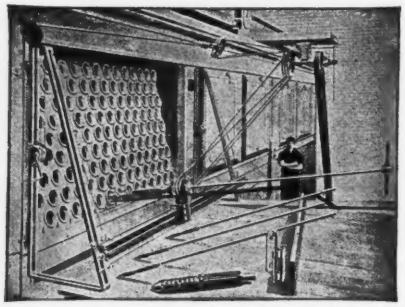
### The Faber Blow-off Valve

washes its face every time it is opened and closed.

A connection at C admits steam at boiler pressure to chamber B, whence it escapes through slot E all around the seat, and sweeps both seat and disk free from sediment just before closing. It will last as long as a steam valve without leaking.

## Liberty Manufacturing Co.

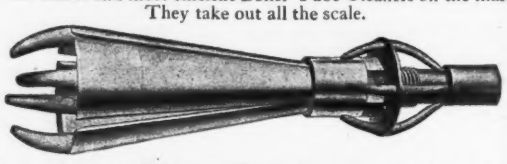
6907 Susquehanna Street - Pittsburg, Pa.



## The Union Boiler Tube Cleaners

**POWER OR IMPULSE**

Are the oldest and most efficient Boiler Tube Cleaners on the market. They take out all the scale.



## The Gem Flue Scraper

does the same for Smoke Flue Boilers

We also make **Gem Oilers,** Patent or Plain, **Torches and Heavy Brazed Steel Oilers, Flexible Shafting, Loose Pulley Lubricator.**

Write for Catalogue and Prices.

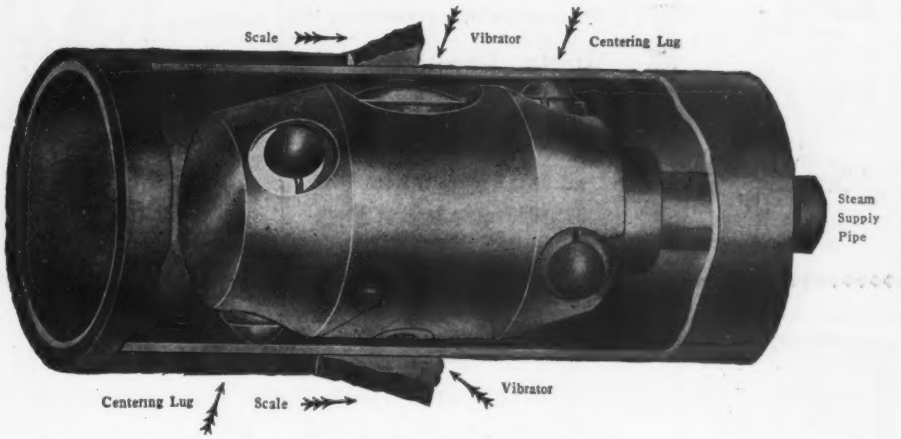
## Gem Manufacturing Co.

Spruce near 33d Street - Pittsburg, Pa.

# TWO WAYS OF BOILER CLEANING

The old way of mechanically cleaning fire tubes is to severely pound the inside of the tubes with a heavy hammer. The new way as found in the "Torpedo" is to rap the tubes lightly but with great frequency. The speedier the movement of the knocker. the lighter can be the raps with the same effectiveness. The scale is then dislodged by the vibration and not by subjecting the tube to the strain and shock of a hard, heavy blow.

Both ways will remove scale; BUT the latter method is the only right way, if due regard is to be paid to preserving the safety and soundness of the tubes




The steam-actuated centering lugs automatically hold the "Torpedo" true in the center of the tube, so that because of a properly equalized stroke, the taps are uniform on all sides of the tube, **including top and bottom.**

All valves, pivots, levers, etc., are entirely absent in the "Torpedo" so that this machine really has but ONE working part.

Recognizing the valve of the important improvements as mentioned above, the "Torpedo" is now superceding every other device for use in fire tube boilers in scores of the most careful and conservative plants in the country.

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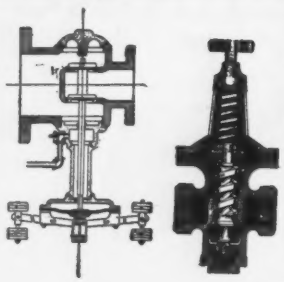

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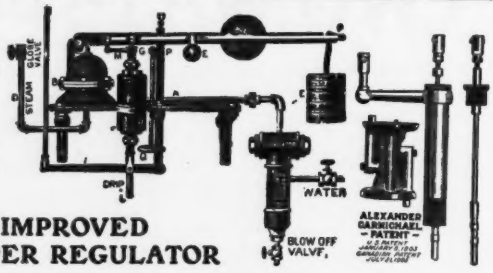


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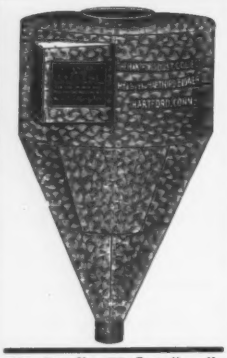

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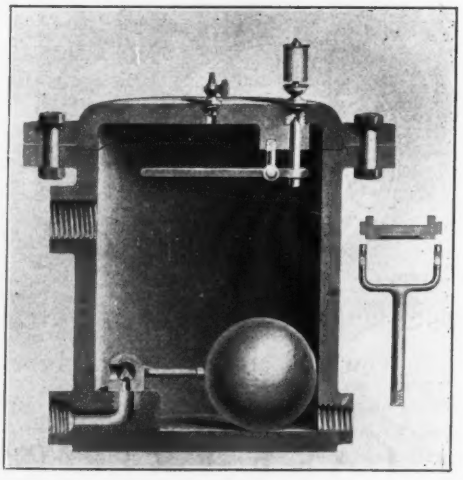

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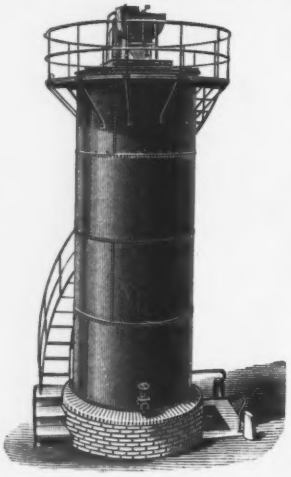

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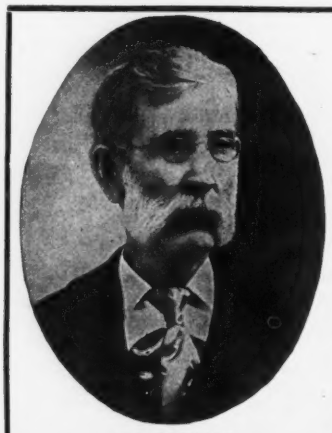

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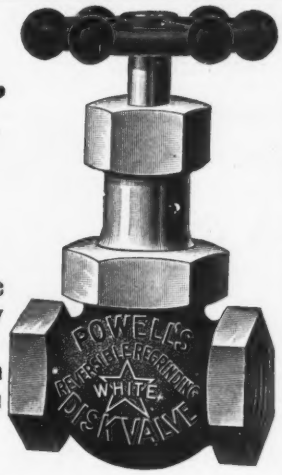


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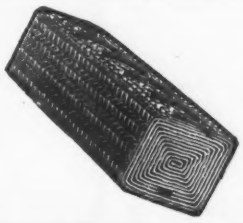

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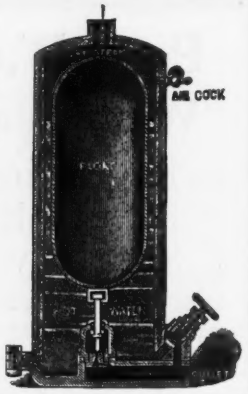


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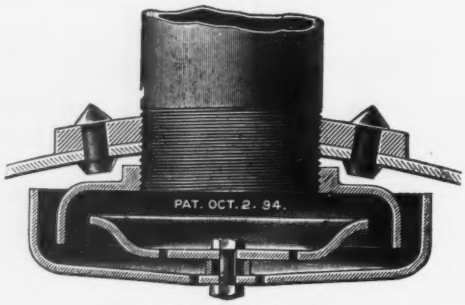


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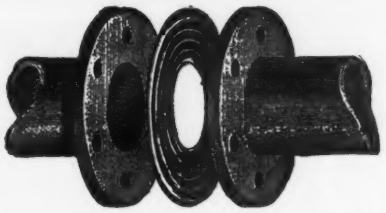

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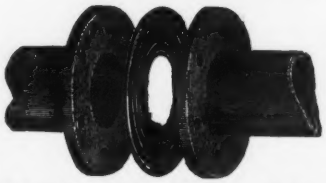

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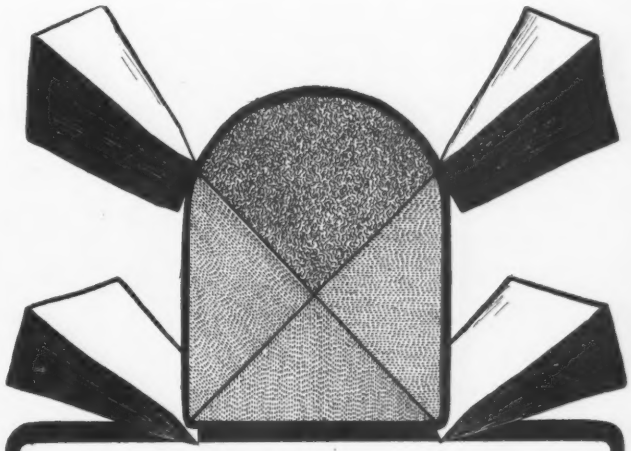

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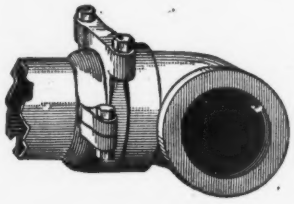

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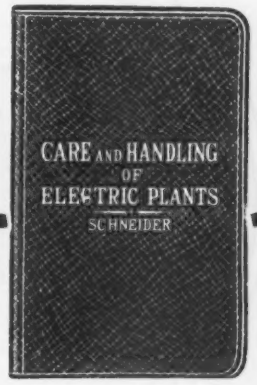


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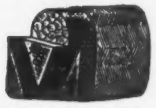

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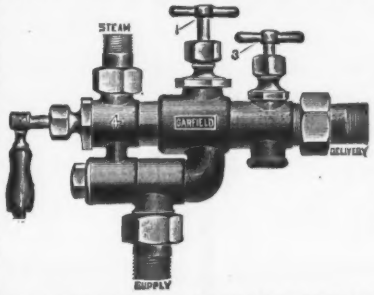


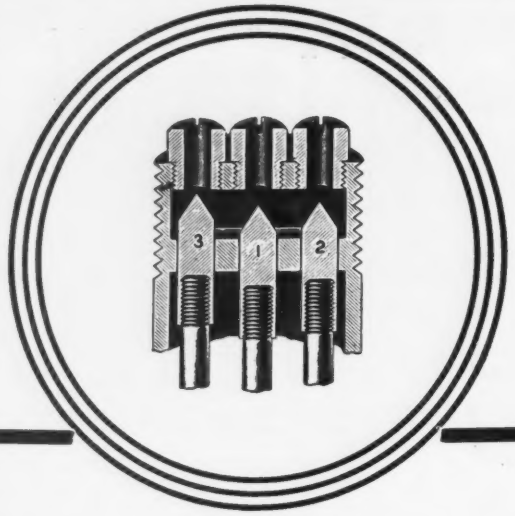

## POWER PLANTS

Equipped with Garfield, Double Jet Injectors and Chicago Sight Feed Lubricators are as satisfactory to the owner as to the engineer.

Boilers steam easily and engines run smoothly.

Send for catalogue and mention THE PRACTICAL ENGINEER.

**The Ohio Injector Company**
**WADSWORTH, OHIO**



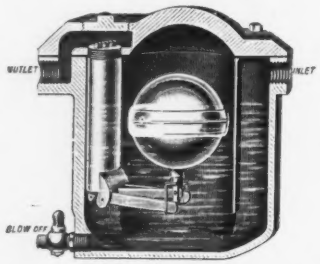

# The "Center of Attraction" for Engineers

When an engineer studies the working principles of the

## Wright "Emergency" High Pressure Steam Trap

the first thing that rivets his attention and pleases his mechanical fancy most is the "three valve arrangement."

Here are some of the observations he's likely to make:




"I like the location of the valves at the **top of the trap.** where grit and scale don't get to 'em."

"That idea of getting at the valves by taking out the iron plug over the tube makes it mighty handy in case of repairs—a 'cut' valve seat could be taken out with a screw driver and replaced by a new one in a jiffy. No disconnecting the piping—no bother of any kind."

"That **hits** me! A trap that does it's work well, but free from complicated parts—put me down for an "Emergency."

**We have a Catalogue. Write for it to-day.**

**Wright Manufacturing Co.**

72 Woodbridge Street. DETROIT, MICH., U. S. A.

# STEAM TRAPS "Nason" and "Sidelug"

**"Nason" Trap**
For pressures to 70 lbs.

**THE STANDARD FOR SIXTY YEARS**

**"Sidelug" Trap**
For pressures from 70 to 150 lbs.

The practical engineer wants nothing but practical devices in his plant. The simplicity of the "Nason" Trap renders it eminently practical. Its design embodies the only correct principle, as is evidenced by its large and continuous sale since its introduction in 1842.

All parts of the "Nason" and "Sidelug" Traps are so removed from contact with dirt and scale as to render their stoppage impossible, thereby indefinitely prolonging their integrity.

Nason Traps are "built for business"—no flimsy material and slip-shod workmanship—consequently no trouble and no leaks.

Wherever condensation is to be removed without waste of steam the "Nason" and "Sidelug" Traps can be successfully applied.

**Every Steam Trap Bearing Our Name is Tested and Guaranteed. Reject Imitations.**
**Complete Catalogue on Application.**

**NASON MANUFACTURING CO.**

Beekman Street NEW YORK

# Heintz Steam Traps

can be placed in any position. We submit proofs for installment free—in fact, we prefer to do this in order that we may guarantee results and prove how much better they are than all imitations.

Proof before pay.

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YOU WON'T BE STUCK

IF YOU USE THE

**Practical Belt Stick**

To make belts pull and not slip does not injure belt but prolongs life worth a hundred times its cost. Don't wait but try it now. Write to-day for

A FREE SAMPLE STICK

**Practical Manufacturing Co.**

RICHMOND, INDIANNA.

**Lamprey Protective Arch Plates**

Protect your boiler fronts from burning out, preserve the brick work, save fuel, and increase the efficiency of your boiler, by giving additional heating surface. Save their cost in repairs alone.

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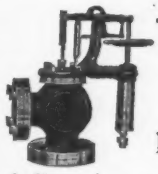
THE LAMPREY CO.
Westfield, Mass.

Philadelphia Shop, 240 Chestnut Street

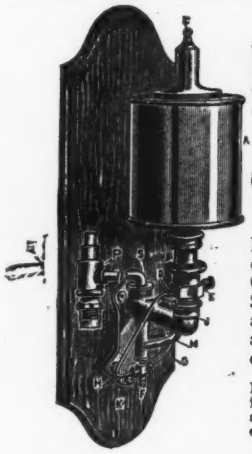


**THE CARR PUMP GOVERNOR**

Send for catalogue and learn how you can save hundreds of dollars in coal bill by using the Carr Feed Pump Governor. 30 days trial.

**E. M. Carr,**

New Castle, Ind., U. S. A.



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**Kellam Damper Regulators**

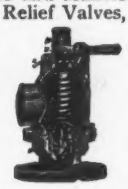
The Simplest and Closest Damper Regulator.

Manufactured by

**J. E. Lonergan & Co.**

211 RACE ST., PHILA., PA.

Brass Founders and Finishers and Makers of Pop Safety Valves, Water Relief Valves, Oil Cups and Lubricators, Steam Pressure Regulators and other safety steam appliances.



Old Kellam Regulators Repaired. Correspondence Solicited. Mention this paper if your inquiry is prompted by the sight of this advertisement. Catalogue D free on application.

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**General Machinists**

ENGINE BUILDERS
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Especial Attention Given to Repairing and Erecting Steam Engines, Pumps and Other Machinery, Shafting, Hangers, Pulleys, Etc., Etc.

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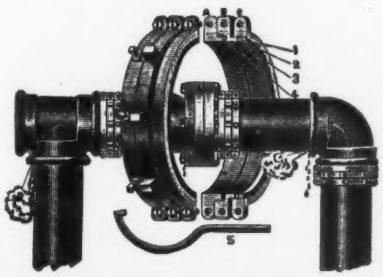
**EVERY CLIMAX STEAM JOINT CLAMP**



is guaranteed to STOP THE LEAK. Made of BRASS for all sizes of pipe, and can be attached in a few minutes without shutting down the plant. Thousands in use, and adopted by the largest steam users as a permanent repair.

**JAMES McCREA & CO.**

MANUFACTURERS

67 W. Washington Street, CHICAGO

## BOILERS CALED?

Boilers pitting?
Boilers corroding?
Boilers prime?
Boilers foam?
Steam Joints leak?
Cylinders hard to lubricate?
Too much moisture in steam?

The Answer — Use Dearborn

"DEARBORN" stands for the Scientific Water Treatment, made to suit the analysis of each water.

"DEARBORN" stands for Treatment that does just what you want it to do.

"DEARBORN" stands for the Treatment that is so thoroughly condensed that you are neither buying nor paying freight on water.

"DEARBORN" stands for the Treatment that absolutely cannot be injurious to heaters, feed-pump, piping, boilers or steam connections.

The nature of practically all waters necessitates your using something if you will find out what all others have done, then investigate what this Company has done, you will without question, adopt DEARBORN WATER TREATMENT in your boilers as a permanent solution of the problem.

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is the only guaranteed one on the market.

Our very large experience in connection with pumping machinery enables us to compound a valve to meet any and all requirements, and we guarantee them to give absolute satisfaction or money is refunded.

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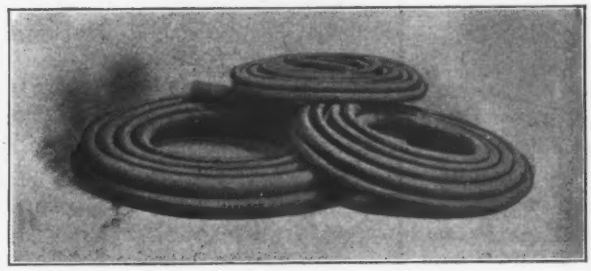
Our Trade Mark is a symbol of reliability, efficiency and economy.

GARLOCKS HIGH GRADE PACKINGS

# Garlock Steam Hose

will positively withstand steam pressure longer than any other Hose made without vulcanizing. Our great success is due to applying the same compound in the hose lining that we have used in our well known high grade Steam Packing for years with unequalled results.



Our Trade Mark is a symbol of reliability efficiency and economy.

WE GUARANTEE ALL GARLOCK PRODUCTS. WRITE FOR CATALOGUE.

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## The Importance of a Reliable Lubricator

The work which a lubricator should do is so vital to the welfare of the engine and to its efficiency in the consumption of steam that it is very poor policy to take any chances with cheaply made or inferior goods. The injury to the cylinders, resulting from imperfect lubrication, would very soon amount to several times the cost of a first class lubricator.

The Detroit Lubricators have been used by fully nine-tenths of the prominent builders of American steam engines for upwards of 25 years, and there are over 700000 of steam in use in all parts of the world. An engine equipped with a Detroit Lubricator will be perfectly lubricated and economically operated. Avoid imitations. Our name is stamped around the body of every lubricator we make, and on the boxes in which they are packed.

**OUR CATALOGUE ON APPLICATION**

**Detroit Lubricator Company,** DETROIT Mich.

**KEEPS BELTS FROM SLIPPING FOR LEAST COST, AND NO TROUBLE**

**THE ADDRESS LABEL on 12 pound Box IS VALUABLE**

**CUT OUT THIS COUPON**

## STEPHENSON MFG. CO.
ALBANY, NEW YORK

Please send me your PREMIUM List.

My name is_____

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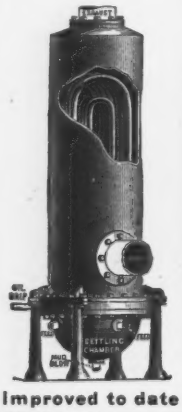
# The Practical Engineer's Favorites



Improved to date

Improved to Date

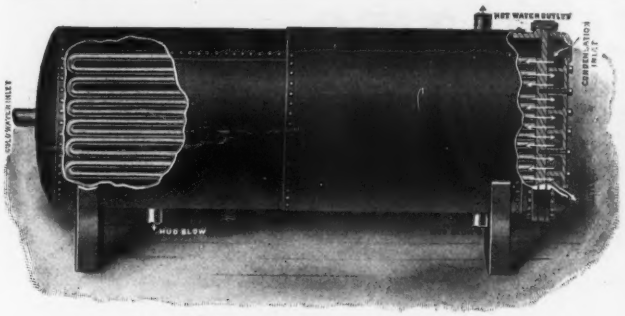
Improved to date

Improved to date

All Practical Engineers like our specialties, (FEED WATER HEATERS; EXHAUST HEADS; SEPARATORS and BELT PUMPS) because they are IMPROVED TO DATE. Because they have so many unusually good points about them. Write us, we will tell you what they are. Remember we can't get hold of your name unless you write us first.

## FRANK L. PATTERSON & CO.

24 CORTLANDT STREET MANUFACTURERS NEW YORK



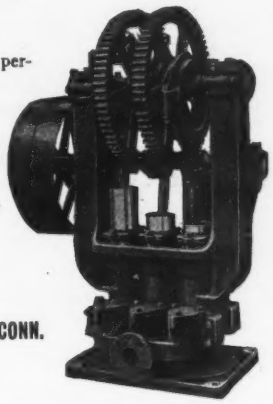
The Gleaner

The **Gleaner** represents the acme of perfection in feed water heating.

THE

## Davis Triplex Power Pump

is a perfect type of the vertical triplex belt driven pump.



MANUFACTURERS OF

**The "Berryman" Feed Water Heater and Purifier.**

**I. B. DAVIS & SON, HARTFORD, CONN.**

WRITE FOR CATALOGUE, ETC., TO

**THOS. McADOO, 125 N. 4th St., Philadelphia**

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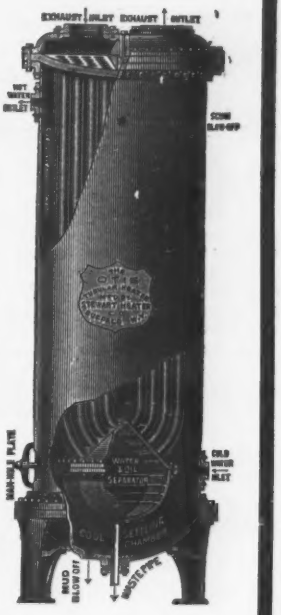
## THE OTIS Tubular Feed WATER HEATER, OIL SEPARATOR and PURIFIER

with Seamless Brass Tubes



### Guaranteed

To heat the feed water to the boiling point (210 or 212 degrees) with the exhaust steam without causing any back pressure, **also to extract the oil from the exhaust,** so that the exhaust steam after being passed through the heater can be used for heating purposes, and the water of condensation for the heating system be returned to the boiler without the additional expense of an eliminator.

### A Liberal Offer

If this heater fails to give satisfaction in every respect, we pay freight, cartage, etc., both ways.

## The Stewart Heater Co.

**11 Norfolk Avenue, Buffalo, N. Y., U. S. A.**

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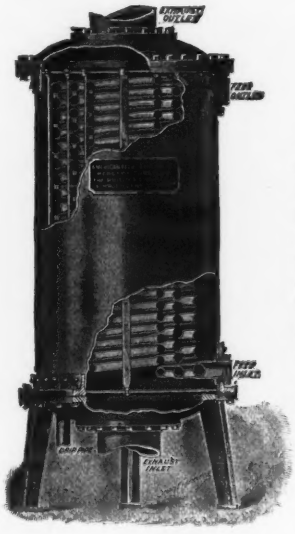
## THE AMERICAN STANDARD COPPER COIL FEED WATER HEATER



**Simplicity!**
**Strength!**
**Economy!**
**A Money Saver!**

It gives so little trouble that one of our customers, who has used one for three years, had forgotten that he had it when we asked him the other day how it was doing. He called in the engineer, who said it hadn't been touched since it was put in and was still heating the water to 210 degrees.

**That's the kind of a Heater you want.**

**Write for Catalogue No. 100 P**

## The Whitlock Coil Pipe Co.

HARTFORD : CONNECTICUT

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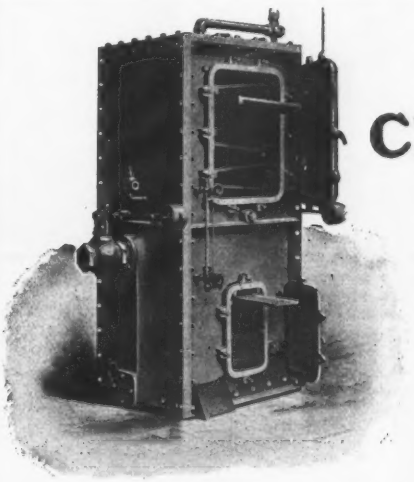

## In Chicago

The big Palmer House uses the Webster steam heating system, feed-water heater and separator. They were skeptical regarding the heater, though—they thought the cylinder lubricants in the exhaust steam would make the hot water unsuitable for domestic use.

Now they write that for four years the heater has furnished a full supply of purified hot water for the entire hotel, as well as kitchen and laundry. It not only removes all traces of oil, but of *lime* as well.

WEBSTER appliances do more than you bargain for.

**WRITE FOR BOOKLET.**

## Warren Webster & Co.

CAMDEN, NEW JERSEY

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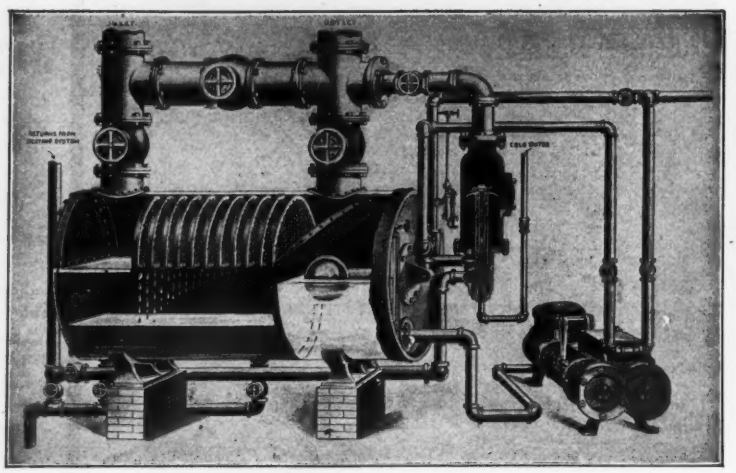
# Utility STEAM SPECIALTIES

**WE POINT TO WHAT WE'VE DONE AS PROOF THAT OIL CAN BE ENTIRELY REMOVED FROM EXHAUST STEAM AND THAT FEED WATER CAN BE HEATED ABOUT TO THE TEMPERATURE OF THE EXHAUST BY**

## Our "Utility" Combination

We can always guarantee an elimination of 98 per cent. at the outlet point af separator. We average over 99 per cent and have in some cases left but 8-10,000 of 1 per cent. of oil in the water. You can't see this amount, you can't taste it; fresh well water frequently has more oil in it, and this water can be used for fifty years in boilers without showing a trace of oil deposit. The feed water heating feature is optional, but very efficient, free from back pressure and requires but little room and no floor space.

The "Utility" Combination serves as Exhaust Muffler, Oil Separator, Return Tank, Pump Governor and Feed Water Heater. It costs only about as much as a Feed Water Heater.



## "Utility" Pump Governor

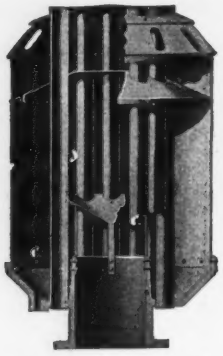
. . . The best Pump Governor on the market. Why? Because our valve will not leak or stick; we guarantee it to absolutely govern the pump and remain tight for five years. Compare the construction of our valve with any other on the market. By adopting the "Utility" you can save coal and get a higher temperature from your heating or drying systems. Send for catalogue and list of users.

## A New Application

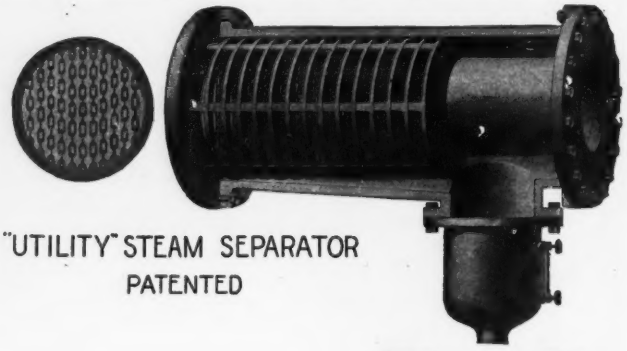
of the chain baffle plate principle which has proven so successful in the oil eliminator may be found in our

## Steam Separator

and the efficiency of it is very high. Absolutely dry steam, absolutely no back pressure. What more could you ask?



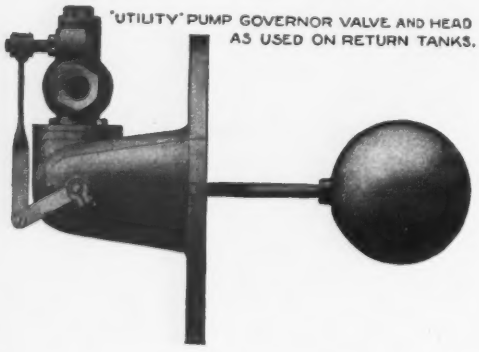
UTILITY EXHAUST HEAD PATENTED



"UTILITY" STEAM SEPARATOR PATENTED

## Another Water Saver

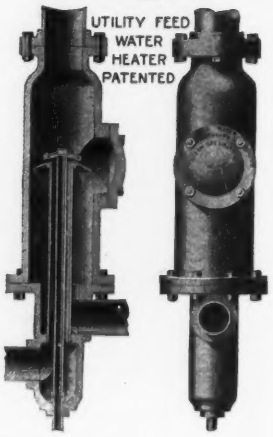
is our new Exhaust Head. Notice the great radiating surface that is given by the CIRCULATING AIR TUBES. These act as condensers, and they lessen instead of causing back pressure. Do you realize that a thousand gallons of water are wasted in a moderate sized plant which lacks an efficient exhaust head? It's so.



"UTILITY" PUMP GOVERNOR VALVE AND HEAD AS USED ON RETURN TANKS.

WE ALSO CARRY IN STOCK

- Back Pressure Valves
- Blow-off Cocks
- Pressure Reducing Valves
- High and Low Pressure Boiler Feeders
- Reducing Pressure Reducing Valves
- Boston Boiler Thermostats
- Steam Traps
- Damper Regulators
- Feed Water Controllers
- "Utility" Beam Clamps



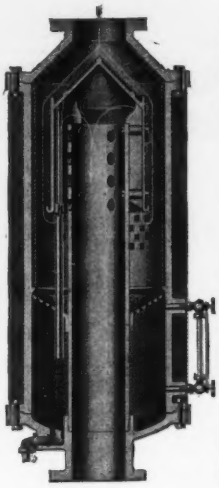
UTILITY FEED WATER HEATER PATENTED

## Standard Steam Specialty Co.

542 and 544 WEST BROADWAY
NEW YORK CITY

PHILADELPHIA OFFICE, ROOM 312, BOURSE BUILDING. BELL TELEPHONE, MARKET 44-95 A

# Sweet's Separators



Our steam separators deliver steam containing less than one half of one per cent. of water.

Our oil separators remove 99 per cent. of the oil.

We can prove they do it and give good reasons why.

In addition they have size and are machines.

Made in all styles, also make Exhaust Heads and Steam Traps.

## Direct Separator Co.

220 Marcellus Street

Syracuse : : New York

# The Baum Separator

Horizontal Style for Live Steam or Oil Service.

**For Live and Exhaust Steam**
**RESULTS GUARANTEED**

For condensing systems use the BAUM VACUUM STYLE OIL EXTRACTOR.

Most satisfactory Separator on the market. Ask why.

The Baum Separator and Machine Company

**Manheim, Pa., U. S. A.**

Vacuum Style Oil Extractor.

**Philadelphia Agents, ANERICAN SUPPLY COMPANY, 612 Betz Building**

# BERRYMAN

## Feed Water Heaters and Purifiers

**WATER TUBE AND STEAM TUBE**

Cast Iron or Steel Shells. "U" Shaped Seamless Drawn Brass Tubes.

**We Build Heaters for Every Purpose and Condition**

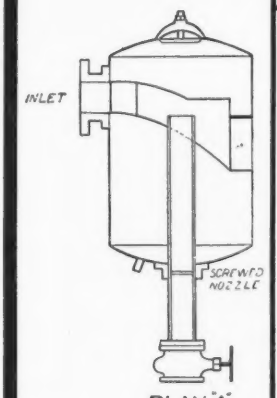
**THE KELLEY PATENT**

**IMPROVED BERRYMAN WATER TUBE FEED WATER HEATER AND PURIFIER**

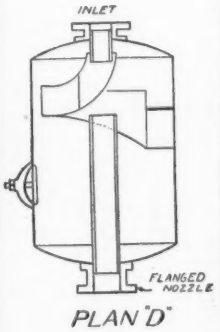
## Benj. F. Kelley & Son - Makers

91 Liberty Street, NEW YORK

# The Simonds Steam Receiver and Separator



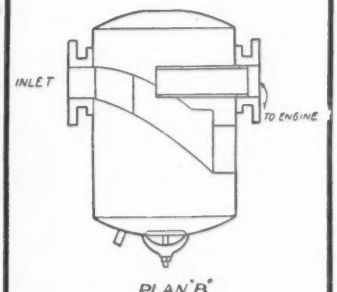

PLAN "A"



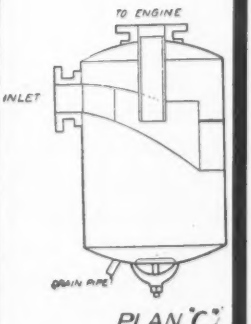

PLAN "D"

**IS BUILT TO FIT ALL CONDITIONS OF PIPE CONNECTIONS, AND EACH IS PORTIONED TO THE CONDITIONS UNDER WHICH IT IS TO OPERATE.**

**Manufactured By**




PLAN "B"




PLAN "C"

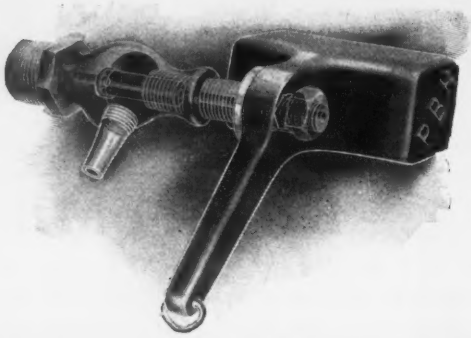
## FRANK A. SIMONDS

**421 HOUSEMAN BUILDING** **GRAND RAPIDS, MICH**

## GET ONE FREE

Put it on your boiler, and give it a good trial for a month; if it gives you absolute satisfaction, keep it, and pay for it, otherwise send it back at our expense.

"P. B. H." WEIGHT GAUGE COCK



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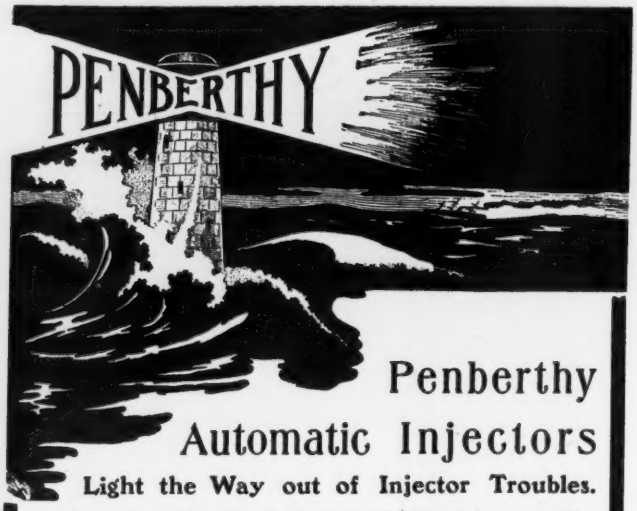


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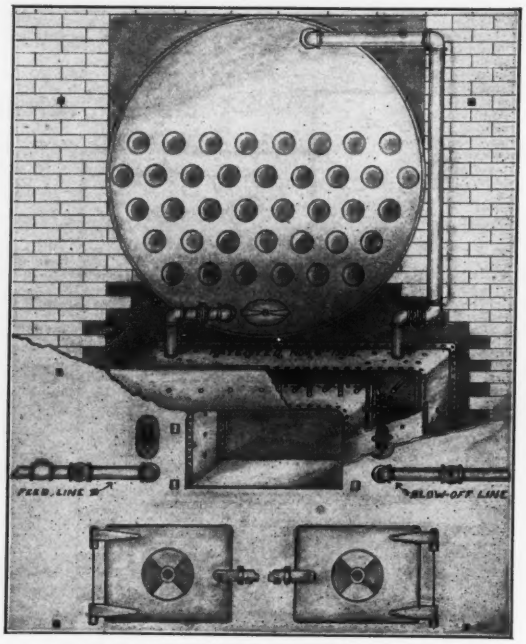


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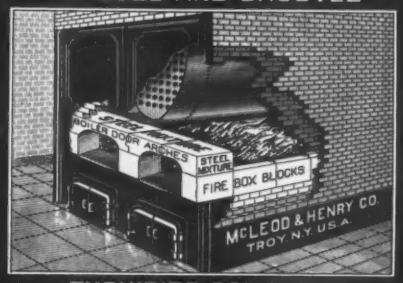


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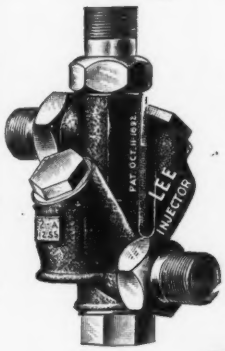


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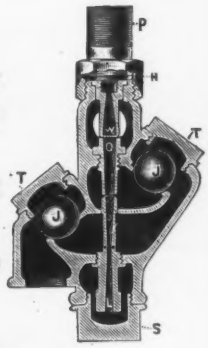


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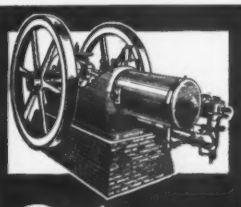

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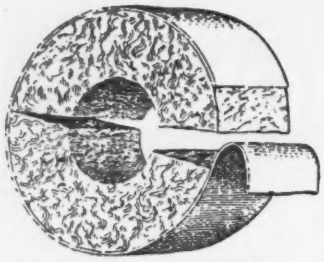

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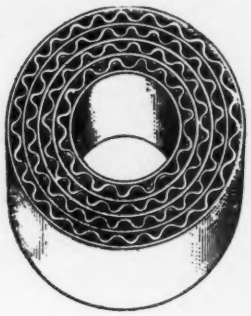

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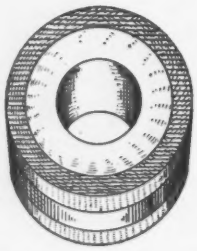

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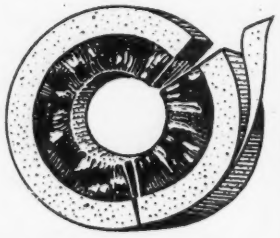

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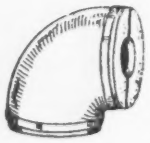

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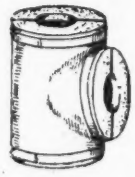

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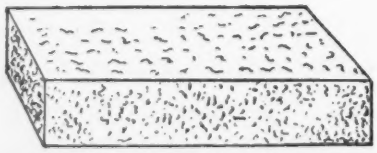

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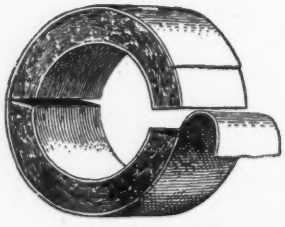

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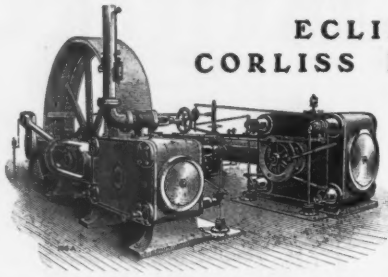

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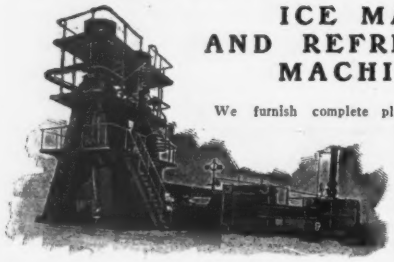

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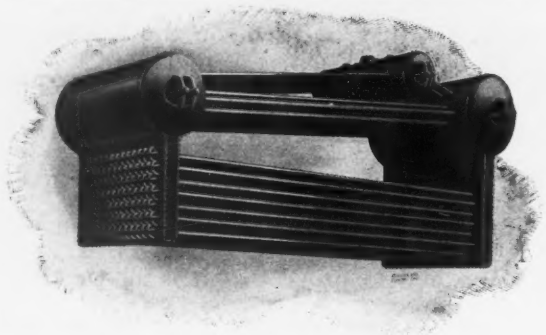

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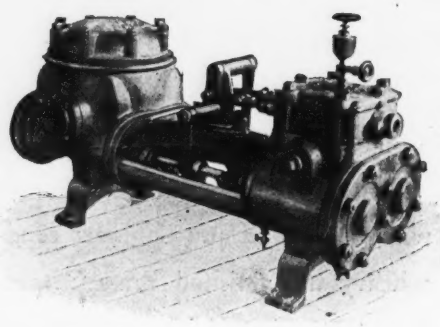

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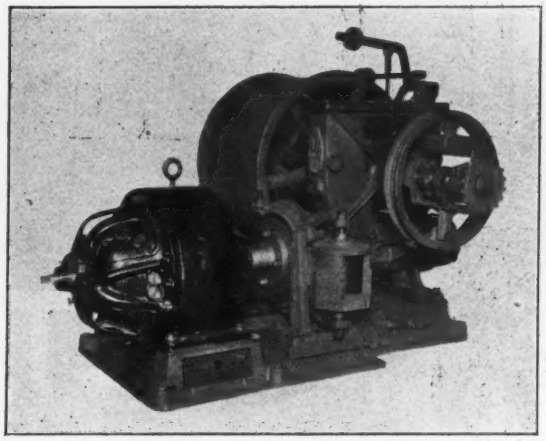

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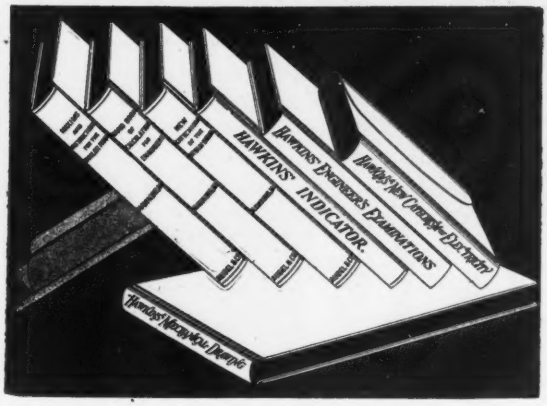


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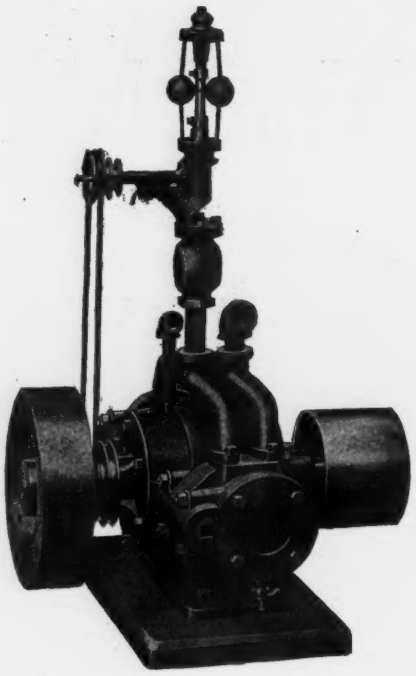

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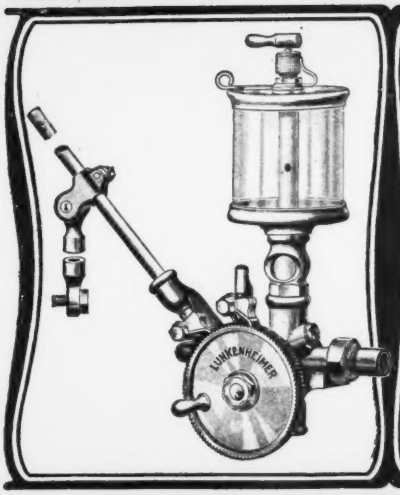


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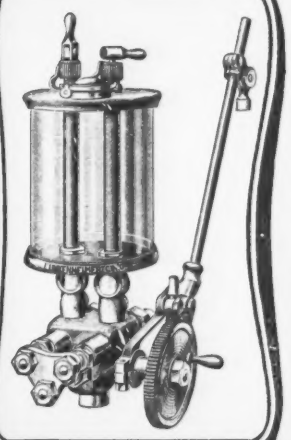

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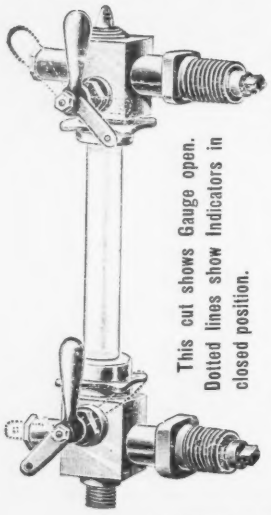
# The Graber Indicating Automatic Water Gauge

(PATENTED.)




**Adapted for BOILERS (Stationary, Marine and Locomotive), SEPARATORS, TRAPS, TANKS and all other places where Gauges are used.**

**A Few reasons Why** the GRABER Indicating Automatic Water Gauges are the best, and the advantages they possess over all other Water Gauges.

1st. They are the only Automatic Water Gauges that indicate at a glance any and all positions of Automatic Valve.

2nd. They are the only Automatic Water Gauges that have but one valve, which serves as automatic and hand moved.

3rd. They are the only Automatic Water Gauges which have no valve-stem to pack; therefore no corrosion or sticking.

4th. They are the only Automatic Water Gauges that remain closed after pressure is off. They cannot fall open.

5th. They are the only Automatic Water Gauges that contain the genuine Jenkins Disc; therefore they will last indefinitely.

6th. They are the only Automatic Water Gauges that are positively self-cleaning and will always shut off tight.

7th. They are the only Automatic Water Gauges that positively prevent false Water level, danger from scalding, and damage resulting from breaking water glasses.

**EVERY GAUGE GUARANTEED. SENT ON 30 DAYS TRIAL IF SO DESIRED**

# Jenkins Bros. Brass Whistle Valve

Our Whistle Valves are made with bodies and disc-holders same sizes as regular globe valves. They contain the Jenkins Disc, are not constantly leaking, and require no regrinding. All parts are interchangeable and repairs can be easily and quickly made.

# Sellers Restarting Injector

**Thoroughly Reliable and Perfectly Automatic.**

Restarts instantly after a temporary interruption of the steam or water supply.

**It has a wide range of capacities, and raises the water promptly with hot or cold pipes.**

All joints are screwed and tubes do not depend on the pressure of steam to hold them in place, and there is no danger of leakage at these important shoulders.

**Body and tubes are made of the BEST BRONZE, and the workmanship is perfect.**

It is easily repaired; the only tools required being a screw driver and monkey wrench.

**All parts are made to gauges and are sold at such figures that the Injector can be practically renewed at trifling cost.**

**Designed for use in all places where a high class, moderate price injector is required.**

**SEND FOR DESCRIPTIVE PAMPHLET.**

# JENKINS BROS.

**71 John Street, NEW YORK** — **133-137 N. Seventh Street, PHILADELPHIA**
**31-33 N. Canal Street, CHICAGO** — **35 High Street, BOSTON**
**62 Watling Street, Queen Victoria Street, LONDON, E. C., ENGLAND**